THE HAWAIIAN PLANTERS' RECORD

Volume XXIII. JULY, 1920 Number 1

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Wireworms as Cane Pests in Hawaii.

By O. H. Swezey.

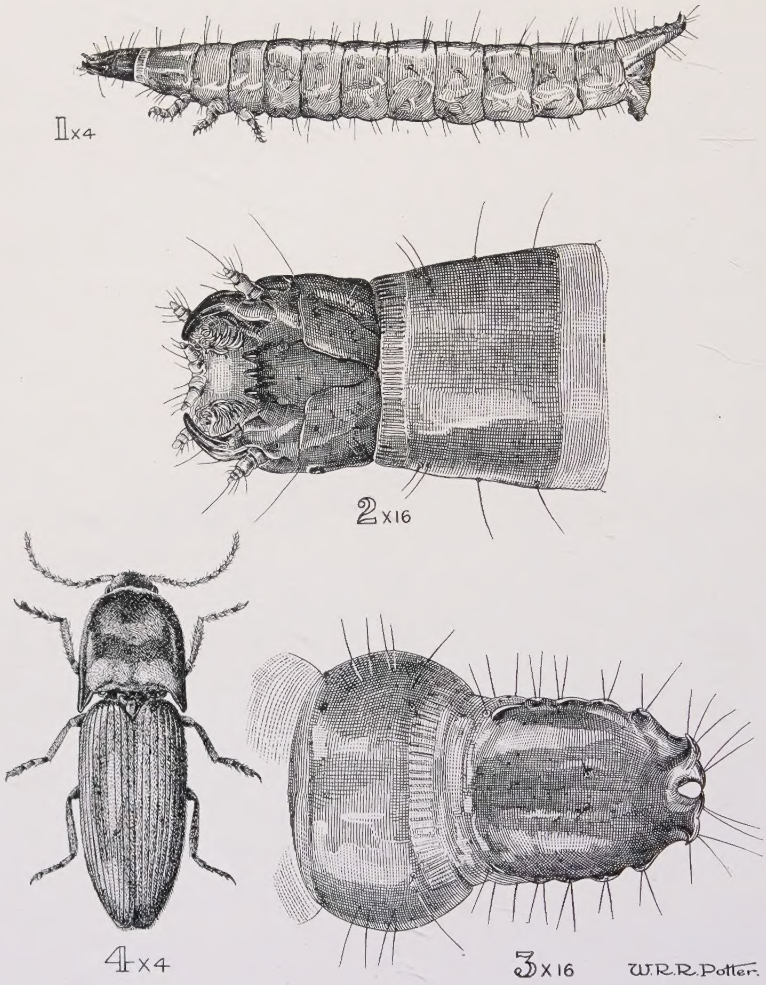
A recent investigation (April, 1920,) in the cane fields at Honokaa Sugar Co., demonstrates that wireworms may become serious cane pests under certain circumstances.

Wireworms are the more or less cylindrical larvae of the Elateridae, a family of beetles commonly called click-beetles, skip-jack and snapbugs. The particular species here concerned is *Monocrepidius exul* Sharp. It has long been known in the Hawaiian Islands, and is an immigrant insect first described from New Zealand, where it was also an immigrant, probably having come from Australia.

This insect first came to our attention as of economic importance as an enemy of the cane borer, its larvae being found to prey on the grubs and pupae of the borer. For an account of this see Planters' Record, III, pp. 7–9, 1910.

A few years later when the *Anomala* grubs were so abundant in certain fields of Honolulu Plantation and Oahu Sugar Co., wireworms of this species were also found among them and were considered of some value as a predator on the *Anomala* grubs. (See Planters' Record, XV, p. 345, 1916.) When kept in close confinement with grubs in soil, a wireworm was found to eat one or more of the grubs daily. As the wireworms have a long period of growth, one of them would account for the destruction of a large number of *Anomala* grubs in the course of its lifetime. There is no doubt but what it is also to some extent predatory on the grubs of the Japanese rose beetle, and many other insects, in fact perhaps taking whatever it can find in the soil suitable to its taste.

From the observations thus far made this insect was considered beneficial on account of the predacious habits of its larvae. The larvae also are of a different type of structure (see the accompanying figures) than the wireworms which have been known to be destructive to plants or the roots of plants. These latter wireworms are more cylindrical, and the posterior end of the abdomen more pointed. We have one such here, *Simodactylus cinnamomeus* (Boisd.),



MONOCREPIDIUS EXUL (WIREWORM).

Fig. 1—Full grown larva, side view. Fig. 2—Under surface of head. Fig. 3—Upper surface of terminal spoon-shaped segment. Fig. 4—Adult beetle.

a larger species than *M. exul,* but its larvae have not attracted particular attention by being abundant enough to produce noticeable injury.

In the investigation of reported injury by wireworms at Honokaa, they (*M. exul*) were found in fields of all kinds of conditions: in stubble where cane had recently been harvested; in fields of about half-grown cane; in fields being plowed; in fields being planted; and in fields that had been recently planted, i. e., one week to two months. These fields were situated in the upper part of the plantation, mostly above the government road and extending to the upper limits of the plantation.

The injury done by the wireworms is the burrowing into and eating of the eyes of seed cane before they have germinated, and also eating into and destroying the tender new shoots which have just started. One to several eyes may be

eaten out on the same seed piece; sometimes all of them are, the wireworms penetrating even beneath the leaf-sheaths, when present, to find the eyes. The destruction of so many eyes and young shoots makes it necessary for a great deal of replanting, later on, to obtain the desired stand of cane in the field. Where several hundred acres are involved, the expense of this replanting will amount to considerable.

In most of the fields examined, the larvae or grubs of the Olinda beetle (*Pantomorus fulleri*) were also found present, in about equal numbers to the wireworms. From our previous knowledge of the predacious habits of this wireworm, it is to be inferred that their presence in the cane fields at Honokaa is primarily as a predator on the grubs of the Olinda beetle. When these grubs are not available, or have all matured, or been consumed, the eyes and tender young shoots of the seed cane furnish attractive food for the wireworms. Where the greatest amount of injury was being done was in a field that had been planted about two months, and none of the grubs of the Olinda beetle were to be found. Either they had already all been eaten, or else had matured, for wherever these grubs were found they were nearly all full-grown, ready to pupate and complete their transformation to adults.

The wireworms also were largely full-grown, and about one-seventh as many pupae were found as larvae in the soil, and in some places a good many adult beetles were found. For about a week the beetles had been coming abundantly to lights in the evening at the manager's house. The indications were that there would soon be a considerable diminution of the wireworms in the fields on account of their maturing. Hence, it would be likely that later planted seed would not suffer injury from them. It should be well started before another brood of the wireworms would come on or be large enough to cause much injury. However, the life history, seasonal occurrence, etc., of these insects are not well known, and special study of them will be necessary to ascertain what bearing they may have on the time to plant cane to avoid wireworm injury. Further observations are also necessary to determine the relation of their occurrence to the presence of the Olinda beetle larvae, and as to the inter-relation of the life cycles of the two insects.

According to publication of investigations on wireworms in other countries, no successful method has been found for poisoning wireworms. Nevertheless, at Honokaa, some experiments have been started with poison and repellents, both in a small way and in the field. Tests are also being made of closer planting of seed in the row, so that even though a considerable number of the eyes should be destroyed by the wireworms, there yet would be a sufficient number left to produce the desired stand of cane, without having to replant later on.

Some fields of Paauhau Plantation were examined and conditions as regards wireworms and Olinda beetle grubs were found to be quite similar.

Both of these plantations have previously reported injury to seed by wireworms, but when visited by an entomologist at that time, not enough evidence could be found to determine definitely what insect was responsible for the injury. They had mostly matured or had disappeared for other cause.

Wireworm Injury to Seed Cane in Other Countries.

Mr. Edmund Jarvis, in Entomology Bulletin No. 3, of the Queensland Bureau of Sugar Experiment Stations, page 17, 1916, reports wireworms (*Monocrepidius* sp.) as injurious in some parts of Queensland. "In 1910 this pest inflicted serious damage to young cane recently planted on alluvial flats at Mackay; and in the same year occurred very freely in the Central Isis district, where it was reported to be causing more damage than any other insect."

Mr. Jarvis gives the following brief extract from a letter by Mr. H. R. Hart, of Mackay, in September, 1915, which serves to illustrate the nature of injuries due to wireworm there: "The worm attacks the eyes of the 'sets' immediately after planting, apparently feeding on the soft content of the eye, and then passing on to the next 'set,' continuing sometimes from end to end of the field. I have known several cases where fields of cane have had to be plowed out and replanted from this cause; and in my own experience I once planted a small field of about two acres three times with the same result."

Mr. Jarvis adds: "Apparently the ravages of this pest are of very local occurrence."

It is possible that the wireworm of Queensland (*Monocrepidius* sp.), mentioned by Jarvis above, is the same as the one we have here (*Monocrepidius exul*).

In Agricultural Report No. 1 (1916), of the Colonial Sugar Refining Co., Mr. Robert Veitch discusses injury to sugar cane "sets" by wireworms in Fiji. There the wireworm is the larva of a different species (*Simodactylus cinnamomeus* (Boisd.). This is a species we have in the Hawaiian Islands, but does not seem to become numerous enough for injury. Only an occasional specimen was found in the Honokaa fields.

According to Mr. Veitch, the greatest injury is done in rich, alluvial flats, where the loss is commonly 40%, and goes as high as 75%, and even 80% has been observed.

The most promising remedial measure proposed there is: "When fields are known to be liable to wireworm injury it is advisable to make provision for failures. This is best done by the continuous planting of a certain portion of the rows. If every fifth row is so planted there is provision for a twenty per cent failure, when the spacing in ordinary rows is fifteen inches from end to end of fifteen-inch sets. When required, the surplus plants should be dug out of the continuous rows and used to fill the blanks in the ordinary rows. This operation should be carried out only when there is promise of rain, always bearing in mind that the earlier it is done the more even will be the stand of cane. New 'sets' should not be used to fill blanks in badly infested fields, as they are at once attacked by wireworms and many of them destroyed. If no rows have been planted continuously to provide for losses it is advisable to dig up a number of ordinary rows at the edge of the field and use their sets to fill the blanks in the other rows. The rows that have been dug out can then be planted as a new block."

Experiments With Sodium Cyanide Against Wireworms in Corn in New Jersey.

Dr. Alvah Peterson, at the New Jersey Agricultural College Experiment

Station, has found that wireworms can be killed by the application of a solution of sodium cyanide, but that it is a very expensive procedure, and requires the solution to be applied at the rate of more than 150 pounds per acre. The most satisfactory results of these experiments are given as follows,[1] showing that they had to resort to crop rotation to meet the problem of wireworm control:

"As a last attempt to kill wireworms with sodium cyanide a number of hills of corn, heavily infested with larvae and in an untreated section of the field, were uncovered with a hoe on June 5 and about one quart of water, in which sodium cyanide was dissolved at the rate of 300 pounds per acre, was poured upon the larvae within each hill and then immediately covered with soil. The same treatment plus an equal amount of ammonium sulfate was also tried on a number of infested corn hills. These hills were examined on June 11 and all the larvae found dead, 15 to 40 to the hill. This drastic method of treating hills is apparently very effective, yet even in this treatment some of the larvae may have been repelled by the sodium cyanide which we do not know of. The results of this experiment show that it is possible to kill wireworms if one uses large doses of cyanide and applies the material directly upon the larvae.

"In conclusion it can be said that wireworms can be killed with large quantities of sodium cyanide, but the amount necessary to bring about a satisfactory control makes this method of soil treatment too expensive for ordinary use in the field.

"Since we were unable to control wireworms satisfactorily with sodium cyanide at the Orange City Poor Farm, a system of crop rotation designed to meet the problem of wireworm control was worked out by Dr. Headlee and Mr. Quinn, which will be put into operation during the coming season."

A Popular Description of Cane Sugar Refining.*

By H. C. Welle.[2]

No doubt most cane sugar manufacturers and beet sugar producers think of the business of sugar refining much as I formerly did,—namely, that sugar is sugar, that refinement into the white product is only a simple step further from its extraction from the sugar-producing plant, and that the real essential in the whole process from extraction to the breakfast table is that part that leaches from the plant its burden of sweetness and puts it into a crystallizable condition. Having been one of the host of beet-sugar workers of the Western States for many years, with a somewhat detailed knowledge of the troubles and development that that industry had gone through to its present high state of technical perfection, my belief was firm that the procedure of the refinement of raw cane sugar,—clean, uniform, fragrant, 96% pure, crystallized cane sugar,—must indeed be child's play, almost beneath the dignity of beet-sugar pioneers!

1 38th Annual Report New Jersey State Agricultural Experiment Station, 1917, p. 479.
* Presented at a special meeting of the Hawaiian Chemists' Association, April 17, 1920.
2 Chief Chemist, California and Hawaiian Sugar Refining Company, Crockett, California.

We all have our blasted visions some time in a lifetime, and I must confess that one of mine flashed before my eyes a short time after my initiation into the sugar refining business. For, what I found there, gentlemen, was not the picture of simplicity that I had imagined. I found it could not be designated truthfully with the scornful term of "laundry," as christened by the Louisianans; but instead, I began to realize that it was a wonderful, involved, complex work, that staggered one with its magnitude of quantities, difficulties, exactions, capital at stake, and possibilities of development.

The art of cane sugar refining is a web of complications, so finely drawn that they are never heard of by the layman and seldom by the raw sugar producer. Before giving you a brief description of the consecutive steps of the refining operation, I shall dwell upon just two of these details as illustrative of my meaning.

Glucose, to a beet-sugar producer, is an unknown substance in his operations, and therefore an ignored and uninteresting one. You cane sugar manufacturers are wiser than that, and no doubt have your joys and griefs with this sugar. But I wonder if you realize its importance to the refiner, at least to a refiner of an alkaline house, where its slightest disintegration in an alkaline medium means a darkening of the immaculate liquors required for the high-grade product demanded by a more and more exacting public; or, whose decomposition (and consequent acidifying of the alkaline liquors) invites a further addition, to prevent inversion, of more lime—lime, a mineral ash, a directly added impurity, every bit of excess of which means an increase of non-sugars entering into the immobilization of crystallizable sucrose. Glucose is the great essential for the production of the beautiful golden soft sugars of commerce, but its slightest abuse gives a dirty-looking, red, unmarketable product instead.

This is just one of the many snares that foul the refiner's path, and I mention briefly the complication of the presence of glucose because it is a subject that you are well familiar with yourselves. And further, I venture to say that many of your troubles of manufacture are also ours to a modified or exaggerated degree. For, although the great variations between ripe cane and green cane, or sound beets and decayed beets, are not experienced in our raw product, the slighter variations of raw sugar as our raw product subject us to the same difficulties. Sugar producers' or refiners' troubles originate, not from the sucrose, but from the non-sucrose, and as refineries are built for the handling of raws of normal non-sugar content, any deviation therefrom, although measured in small percentage, affects operations just as much and just as aggravatingly and expensively as the wider variations experienced by the producer of sugar from the plant itself.

You have all heard, time and again, of the damaging influence of ash and sulphates in refining operations—I should say, that you have really only heard whisperings about these obnoxious ingredients of raw sugar, for to really be able to understand the viciousness of the trouble resulting therefrom, you must actually be in the midst of the refinery battle against this enemy. But, as you have heard the subject spoken of off and on before, I shall dwell on it no longer, but shall mention only one more difficulty before proceeding to a brief description of the process of refining. The difficulty of which I now speak will prob-

ably be of more interest than the subject of ash and sulphates, because lack of understanding has very largely kept the subject out of print. Serious though it is,—more serious than is generally recognized, because, first, numerous refinery troubles are due directly to this, but not realized; second, if realized, are not run to ground. I refer to iron—something that has no interest to the raw sugar producer, but is of the most vital interest to the refiner.

Every schoolboy entering the sugar business reads in any sugar text book that he picks up that iron in liquors makes gray sugars, and then forgets all about it, because, without explanation as to where it comes from, what form it is in, how to remove it or keep it out, or how it injures sugar, it naturally seems more like a superstition or guess than a truth. However, it is far from being a superstition—it is, rather, a very aggravating truth that becomes very vivid in refining operations whenever it appears. The difficulty in dealing with the matter lies in the fact that the iron, which enters the refinery in the raw sugar itself, is not in the familiar precipitable form which is so often encountered in minerals. On the contrary, it is organically combined to form a soluble salt which is not decomposed and precipitated by any of the ordinary precipitants of iron. Ordinarily, the iron will indicate its presence in the liquors by their darkening rapidly after char-filtration. The most serious immediate result is rapid darkening of the soft yellow sugars, which, although having the proper shade of color when manufactured, often are greatly changed in appearance by the time they reach the trade. Barrel syrup is affected in the same way.

As the art of refining is now practiced at Crockett as well as in the East, we find in actual operation with Hawaiian sugars that the intensive char-filtration first seems to disintegrate the iron organate, with the result that the organic radical is absorbed and held by the char while the iron is liberated and remains suspended in the liquor in a semi-collodial condition. The great amount of sulphates in the Hawaiian sugars are found to very quickly (within one month) saturate the char up to its selective capacity for sulphates, and these, in turn, break down (under the influence of heat during the char regeneration period) into a relatively large sulphide content. The result, chemically, is obvious—the semi-colloidal iron in the liquors, coming in contact with excess sulphides of the bone-char, results in semi-colloidal black sulphide of iron which contaminates the best liquors in the plant by making them very smoky in appearance, giving the white massecuite a black cast, degrading the granulated sugars, and, worst of all, positively ruining the yellow soft sugars.

Of course, the actual percentage of the objectionable iron is extremely small, but those of you familiar with the colloidal sulphide of iron know that a very little goes an extremely long ways. It only serves to illustrate the difficult factors involved in refinery work. In this instance, in order to carry the work to ultimate refinement, the extremely small amount of iron had, of course, to be removed. Although a new problem to us, it is gratifying to be able to say that we managed to do this in a comparatively short time and we anticipate no more trouble from this source.

Having gone to some length in mentioning the nature of the careful refinements necessary for successful work, you may be interested in now hearing just what the procedure of the refinery is.

First, however, let us consider the question: What is *refined* sugar?

Refined sugar, as we know it, is the result of the developed esthetic taste of people of the present age, and as long as humanity continues to develop that way, the refining of sugar will continue to live, and must continue to develop. People persist in wanting the best, the purest, the most beautiful, whether it be on their bodies, before their eyes, or in their stomachs. Refined sugar comes from the raw, impure, crystalline sucrose product, which has been melted, has had the maximum quantity of impurities removed by filtration, decolorization with bone-char (which is still considered the most efficient medium for the purpose), and re-crystallization into pure white sucrose crystals of, practically, 100% purity. What other food product is there that has such a degree of refinement?

Refined sugar, as the term is usually understood, is distinguished from white beet sugar or white plantation cane-sugar in that the latter two are produced from the raw liquors directly extracted from the beet or cane, with a *partial* process of purification, without, however, having the maximum amount of obnoxious coloring matter and odor removed as is the case in the refining of raw sugar by means of bone-char.

Sugar refining is, as most other industries, a gradual development to meet the demands for a finer product. Although it seemed to reach a stage of self-content which was maintained for many years, it undoubtedly is again beginning to make strides ahead in all parts of the country, and, we believe, particularly in the West.

You all know how we receive the raw sugar—in burlap bags approximately 125 lbs. net in weight, some soft and some exasperatingly hard, much good sugar and some not so good. All of it is trucked over scales presided over by one representative for the planters and one for the refinery. Each truck holds five sacks, and a sample from each fifth sack is composited in covered sample cans corresponding to the mark sampled, the samples being taken by a tryer to the middle of the sack. When the ship is unloaded, these cans are taken to the sample room, where the samples are thoroughly mixed by the representatives of both parties and divided into four parts, one going to the refinery laboratory for analysis, one to the laboratory of the A. A. Brown Co. in San Francisco for analysis, a third being held for referee analysis if necessary, and the fourth going to the refinery laboratory for the physical tests, such as we have been sending to the Islands for the past couple of years. To insure accuracy, all tests are made in duplicate, the instruments of precision always being tested by means of government certified standards before each lot of tests. The actual weighing of the raws received is controlled, checked and reported through a system of great detail under the control of a special department of weights and measures, the fundamental basis of which is the use of weights standardized and certified by the government. The bags of raw sugar are carried into the refinery on endless conveyors and belts, to the cut-in station, where they are discharged onto a long receiving table. Laborers here open the bags and dump the contents through a grating into the raw sugar bin, holding, when full 1500 tons, or approximately one day's run with our present equipment. The magnitude of this work alone will be more vividly realized by understanding that this means 24,000 bags every 16 hours (this work being confined to two shifts), or 25 bags per minute. Ob-

viously, under these conditions, caked raw sugars hamper the work of this station greatly. Ordinarily, the cargoes are stored temporarily in the warehouse, from which a number of different marks are fed into the refinery at the same time. If one of these marks should be badly caked, the cut-in station will, of course, have its difficulties, but the operation of the plant as a whole may continue in a normal manner by sending in a greater proportion of the softer sugars. In a time of slow shipments, however, such as the present season, most of the sugar must, necessarily, be sent directly from the ship to the cut-in station. If, then, a preponderating mark of the vessel is badly caked, the conditions at the cut-in station become so very severe that the capacity of the plant is greatly reduced unless a large excess of labor is employed and a necessary disregard is observed towards saving the empty bags in an undamaged condition. Very large shipments have been received in such a condition this year that the conveying apparatus has been injured, and heavy mauls have been required not only to break the sugar sufficiently to remove it from the bags, but also to force it through the grating of the sugar bins.

The empty bags are now sent to the bag laundry, where the adhering sugar (approximately 4 tons per day) is saved in the form of sweet-water. The raw sugar is removed from the bottom of the bin, elevated to the ninth, or top, floor of the melt house, and is there continuously discharged into two minglers.

The refining operations begin at this point, for as the golden stream of raw sugar pours down the chute from the top of the elevators, it falls directly into its first bath. The cleansing begins by the sugar being mixed, in what is termed the mingler, with a mixture of water and wash syrup, the latter resulting from this same procedure earlier in the day. This mixture with water and cold wash syrup (technically termed "affination syrup") results in a magma of 90° Brix cold. The latter is discharged into a mixer on the floor below, from which it is drawn into centrifugal machines. The object of this procedure is two-fold: first, to provide suitable means for washing the raw sugar, and, second, to soften the enveloping molasses of the raw sugar to a sufficient degree to facilitate its removal.

Twenty-two direct connected, electrically driven Watson-Laidlaw 48″ centrifugal machines (the last word in this type of machinery for the purpose) are employed for the purging of the affination magma, and it is expected that these machines will handle 2200 tons of raw sugar per day. The machines are open at the bottom, and are self-dumping, the discharge being 710 pounds of washed sugar. They are loaded five seconds after starting, while running at a speed of 250 R. P. M. In 25 seconds the machine is completely loaded and running at a speed of 650 R. P. M. During the next 45 seconds the machine has acquired its full speed of 870 R. P. M., and an average of 34 pounds of water in the form of an evenly distributed spray is then applied as a wash during the next 75 to 90 seconds. Spinning is continued for 30 seconds, at which time the power is shut off and the machine stopped in two minutes, the charge of washed sugar dropping out a moment before the machine comes to a complete stop. The self-dumping feature depends entirely upon the gravity of the sugar itself and upon the fact that the diameter of the basket is ½ inch larger at the bottom than at the top. The result of this entire procedure of mingling and washing is to pro-

duce, by separation, a washed sugar of at least 99.0° apparent purity and an affination syrup of 80° apparent purity, from an original raw sugar of approximately 97° apparent purity. As before stated, the run-off from these centrifugals (affination syrup) is partly returned to the minglers to enter into the raw sugar magma. The balance of the syrup is sent to the char house for a special treatment which will be described later.

The thoroughly washed light-yellow sugar now passes into a large storage bin with a long trough at the bottom running the length of the bin, in which it is mixed with hot sweet-water from another part of the plant. As it is mixed, it is conveyed to a discharging point where it runs into the melts on the floor below for completion of solution.

Contrary to expectations, after viewing the rather pleasing light-colored washed sugar, the washed sugar liquor of 62° Brix (at 80° C.) proves to be a brownish, dirty-looking liquid, colored and made turbid from the coloring matter in the crystals themselves and from the fiber and cush-cush hidden in between the individual crystals. Differences in the coloring content of various raw sugars is very apparent at this point, as would be expected when consideration is given to the fact that the crystals of certain Hawaiian raw sugars of equal polarization and purity contain from two to three times as much coloring matter as others. This is a very important matter to the refiner, for it means simply that the burden of the char to keep the production of white granulated sugars up to maximum with one char filtration is two to three times greater with certain sugars than with others of better grade.

The washed-sugar liquor, having been limed continuously to a phenolpthalein alkalinity of 0.003 to 0.004 as it passes through the melters, is pumped to the ninth, or top, floor of the char house. Here it goes to the blow-up tanks, through which it passes as a continuous operation, getting its addition of kieselguhr at this point, its allotment of No. 1 remelt sugar liquor from the pan floor, such steam as is required to maintain a temperature of 80° C., and sweet-water for final adjustment to the standard density.

The use of kieselguhr to aid filtration is not new in beet sugar house practice, but it has been extensively introduced into refinery work only during the last five years, and is the natural accompaniment of *pressure* cloth filtration. With the old system of bag-filtration (still largely in vogue in Eastern refineries) the advantage of the use of kieselguhr was rather negative. With the introduction of pressure filtration of refinery liquors, however, entirely with the Sweetland filter, the use of some such filtering medium as kieselguhr became an imperative matter to insure its success. In fact, it can be safely stated that, as far as our present knowledge goes, clear cloth filtration of high density raw liquors through pressure filters could not be accomplished in an economical way without the use of kieselguhr or some other such material yet to be discovered.

As the use of kieselguhr is, I think, a subject foreign to Island practice, a little description of it may be apropos. Kieselguhr is a diatomaceous earth,—that is, it is the deposit of myriads of microscopic skeletons of sea organisms of previous geologic periods. In Santa Barbara County of California it is mined in large blocks, brilliantly white, and is then worked down to a very light, fluffy

powder, capable of passing about 200 mesh. Microscopical examination will display many forms of the skeletons, all beautiful in design, but only the round, porous type are supposed to possess the characteristics required in sugar-house work. Chemically it consists of silica, between 80% and 85%, with calcium carbonate, aluminum and iron oxides, and organic matter as impurities. The diatoms are very porous, and for some reason, not clearly understood, they have a remarkable power of facilitating cloth-filtration of otherwise very difficultly filterable, gummy solutions.

The washed-sugar liquor, now having been prepared with lime, kieselguhr, and heat, is picked up by centrifugal pumps as it leaves the blow-up tanks, and is sent through the Sweetland presses at a pressure rising gradually from 10 lbs. to 60 lbs. The muddy brown washed-sugar liquor now appears again before us, as it runs from the presses in the form of a beautiful, sparkling, amber liquor of 62° Brix, for the first time really appetizing in appearance. Fourteen of these presses are used for the filtration of the washed-sugar liquor, each one capable of filtering the liquor of from 100 to 130 tons of raws per 24 hours. Interior sluicing is utilized in cleansing the cloths of accumulated mud, this procedure being necessary approximately every hour. Although accompanied by many discouragements during the introduction of these presses in our refinery, sufficient time has now elapsed to have clearly demonstrated that the use of Sweetland presses is the greatest step in advance in the filtration of refinery products in many decades. An enormous saving in labor, effective maintenance of densities, immaculate cleanliness, and, above all, positive assurance of sparklingly clear liquors at all times, have confirmed to everyone's satisfaction the wisdom that prompted the installation.

The filtered liquor is now ready for the treatment that makes a refinery most distinctive in its operations from a beet-white or plantation-white sugar plant. I refer to the bone-char filtration which the liquor enters upon soon after leaving the Sweetland presses.

For the sake of the uninitiated—bone-char is made by heating the hardest bones in kilns out of contact with the air. The organic matter which is part of bones is thus charred to a black carbon. After breaking up into the required grist, washed, etc., it contains about 10% carbon, the bulk of the remainder consisting of the main mineral constituent of bones, calcium phosphate. In other words, we have now for use in the refinery, a black, hard, very porous material, of the size of fine gravel, consisting of a skeleton of phosphate of calcium, covered, in its most microscopic portion, with animal carbon. This char has, together with many newly discovered vegetable carbons (one of the most perfect of which your own Mr. S. S. Peck is the inventor of), the remarkable property of absorbing the coloring matter of sugar liquors into its pores and retaining it there most tenaciously.

This property of bone-char is taken advantage of by the refiner for removing the coloring matter of the raw sugar liquor, which, if not accomplished, would make the manufacture of white cane sugar much more difficult and of a very unsatisfactory nature for the trade.

The bones utililzed for this purpose come from all over the world. A great deal of char in this country is manufactured from the bones collected in the

great slaughter houses of the middle West, but because of their having been through a boiling process they are inclined to produce a char somewhat low in crushing strength. Our experience would tend to indicate that the best bones for the purpose received on the Pacific Coast are those gathered on the great stretches of cattle lands of India.

The char-filtration of refinery liquors and syrups, with the associated activities of the pan floors, is such a very complex subject that it can hardly be touched upon in a paper of this scope. I think it will be necessary, therefore, to confine myself to a brief enumeration of the liquors and syrups put on to the char, those leaving the char, the pans boiled, the appearance of these products, and a description of the final output. The details of rates of flow, routine of filtration, rendement of liquors, elimination of ash and organic matter and re-filtration, can hardly be described at this time.

It must suffice, then, to state that the char house is divided into three parts, graded according to the quality of the char, No. 1 char being the oldest and therefore the poorest, No. 2 char being of medium quality, and No. 3 char being the best quality. The No. 1, or oldest, char is used solely for the first filtration of the Sweetland filtered affination syrup (which, it will be remembered, resulted from washing the raw sugar in the Watson-Laidlaw centrifugal machines). This syrup has passed through the blow-up tanks and Sweetland presses (10 in number) in the same way as washed sugar liquor, but, because it contained most of the impurities of the original raw sugar, is a muddy, very dark syrup until it has passed through the Sweetland presses. It appears then at the char filters as a beautiful, sparkling liquor, of the color of dark port wine.

The affination syrup, then, passes first over the No. 1 char, is re-filtered over the No. 2 char, and receives another char-filtration over the No. 3 char. In practice, it works out that this syrup receives about 3½ char filtrations, the final result being an amber-colored liquor of about 90° purity (an increase of 10 points from the original affination syrup), suitable for one pan of white granulated sugar, the syrup from the latter being used principally as the base for Golden C soft sugar.

The No. 2 char is used for the filtration of all the washed-sugar liquor, part of the granulated syrups from the white pans, and for the second filtration of the affination syrup. All of the char-filtered washed-sugar liquor produces white sugar; a considerable portion, being nearly water-white, is used for the production of cube sugar and the confectioner's large crystals.

The No. 3 char, having the finest cutting edge, is used for making the darkened granulated syrups and remelt sugars suitable for re-boiling into specialties and granulated, and also for giving the final refinement to the affination syrup, so that it, also, will be suitable for white granulated.

To summarize—the total number of products going on to char is 13, and the total number of grades leaving is 11. Of the latter, 7 grades go to the pan floor, the other 4 being returned to the char for re-filtration. Of the 7 grades of liquors going to the pans, 6 enter into the production of white sugars and one is used as a base for soft sugars.

The char-filters are run on liquors for a period of approximately 30 hours,

the balance of the 73-hour cycle being taken up with sweetening off, washing of char, draining and blowing down with air, emptying, and filling with fresh char.

The liquor gallery is largely the control point of the char house. It is here where the char-filtered liquors are closely watched, and it may be said that if inspection shows an abnormal condition of the char-filtered liquor for any length of time, it can be taken for granted that practically the entire balance of the refinery will encounter some difficulty later. The grading of the liquors, as they leave the char, according to purity and color, is conducted here, they being deflected into one or other of the various troughs according to what use is to be made of them.

When the allotted amount of liquor has passed through the char-filter, it becomes necessary to sweeten-off the filter with hot water, the sweet-water being conducted to the evaporators on the second floor of the refinery for concentration to a thick syrup. The sweetening-off process is continued until purity tests made in the liquor gallery indicate molasses purity. The washing is then continued to waste until all remaining sugar and most of the mineral salts absorbed by the char have been washed out. The sugar remaining in this discarded water is such a small quantity and is of such a low purity, because of the mixture with the washed-out impurities of the char, that it would be detrimental rather than beneficial to try to save it.

Before following the liquors any further from the liquor gallery, it will be well to tell you what strenuous treatment the char goes through before being ready for another period of hard work. Notwithstanding that it has received a most thorough hot-water bath, so complete as to remove most of the mineral salts and organic matter absorbed from the liquors, it has with great persistence refused to give up certain other organic matter, such as the gums that have passed along with the sugar from the day it was first expressed from the sugar-cane. These gums, in fact, may be said to have "gummed up the game" very completely by smearing themselves into the microscopic pores of the char during the filtration of the liquors, and clogging them so effectually that, even after the thorough washing described, the char has but a fraction of its former efficiency in decolorizing any liquors that might then be passed over it.

The universal custom for meeting this condition is to first pass the drained, but very wet, char through driers that partially dry it, and then through retorts of kilns heated by oil fires. The char, in passing through these char-kilns, is heated to from 700° F. to 800° F. out of contact with the air. The result of this procedure is to char the gums obstructing the pores to carbon, without endangering the bone-char to possible destructive combustion. This phase of the process is most important, as upon it depends the future condition of the char (which is the most important single element in the refining), and therefore, also, the degree of excellence of the subsequent work of the refinery. The kilning of the char may determine either highly satisfactory general refining results, or it may completely demoralize the entire plant. The immediate control of this work is conducted by tests made in the liquor gallery. After the char leaves the retorts of the kilns, it passes through a greater number of smaller tubes made of light iron for the purpose of cooling it. It is then fed down to the first floor,

from where it moves by means of elevators and conveyors back into the char filters, ready for another period of active work upon the liquors. No char (valued at present at $180 to $200 per ton) is ever discarded except the impalpable dust accumulated in the dust collectors, and that falling through a fine screen as it passes through the conveying system.

To come back to the liquors which we left at the liquor gallery, after having passed through the char. The liquors are pumped from the troughs of the gallery, through copper pipes, to the various storage tanks of the pan floors of the refinery proper, as distinguished from the char house. The principles involved from this point on are the same as in all other modern sugar plants of the world, be they engaged in refining sugar, extracting sugar from the cane of the plantations, or from the sugar-beet, namely, evaporation and crystallization through boiling under a reduced atmospheric pressure, separation of the sugar crystals from the mother-liquor by means of centrifugal force, and drying of the purified crystals through circulation of heated air.

The best liquors leaving the char are practically water white, having an apparent purity of approximately 99.0° to 99.5°, and these liquors are used for the manufacture of the large-grained confectioner's sugar (Con A and Con AA, we call them) and for manufacture of cube sugar, so that we may truthfully say that the cube sugar on your table is as near to absolute purity as any commercial product made, except some so-called chemically-pure chemicals. In fact, it probably *itself* can be accepted as a so-called chemically-pure product.

The next best grades of liquor, four in number, grade down gradually in color to a straw-colored No. 4 liquor, these all being the base for white granulated sugars. Itemized, then, the white sugars are as follows, the purities stated being in each case the apparent purity:

1. Cube Sugar—From 99.5° to 99.0° purity liquor—Syrup swung off, to No. 1 liquor tanks.
2. Con A Sugar—From 99.5° to 99.0° purity liquor—Syrup swung off, to No. 1 liquor tanks.
3. No. 1 Sugar—Four grades, all based on next best liquor from the char, called No. 1 liquor, with syrup from previous strike boiled back, as follows:
   (a) 1A Sugar—From No. 1 liquor straight, 98.5° to 97.0° purity—Syrup swung off, 97.6° purity, called 1A syrup, to next strike.
   (b) 1B Sugar—From No. 1 liquor and 1A syrup—Syrup swung off, 97.0° purity, called 1B syrup, to next strike.
   (c) 1C Sugar—From No. 1 liquor and 1B syrup—Syrup swung off, 96.5° purity, called 1C syrup, to next strike.
   (d) 1D Sugar—From No. 1 liquor and 1C syrup—Syrup swung off, 96.0° purity, called 1D syrup, sent back over the best grades of char.
4. No. 2 Sugar—One grade, from the next best liquor from the char, called No. 2 liquor, 97.0° to 94.5° purity—Syrup swung off, 92.0° purity, sent back to the best grades of char.

5. No. 3 Sugar—One grade, from the next best liquor from the char, called No. 3 liquor, 94.5° to 91.5° purity—Syrup swung off, 86.0° to 90.0° purity, sent back to the best grades of char.
6. No. 4 Sugar—One grade, from the last grade of liquor used for white granulated, called No. 4 liquor, 91.5° purity, down to a color standard, the average being about 89.0° purity—Syrup swung off, 80.0° purity, sent to either the soft sugar pans or the remelt pans.

From this it will be seen that we boil our white granulated sugars from seven distinct combinations of liquors and syrups, in a definite, predetermined, uniform system, conceived with the idea of getting a maximum granulated into the bag directly from the raw sugar, with a minimum production of remelt sugar. The sugars from all these pans are mixed together, dried, screened into the various grades through Newaygo and Whip-tap separators, passed over magnetic pulleys to remove metal specks, and finally packed. The combination results in a product perfectly satisfactory to the trade, all output first having to pass the critical eye of the Sugar Inspector, whose duty it is to reject any lots not, in his judgment, well within the grade limits, his judgment being final, regardless of any contrary views of the operating staff.

The present pan equipment for the production of white granulated sugars is as follows, all being coil pans and using both live steam at 60 lbs. pressure and exhaust at 12 lbs. pressure:

Cube	1 — 6-foot pan
Con A	1 — 12-foot pan
Granulated	4 — 14-foot pans

Two more pans are to be installed this year, of the calandria type, 14 feet in diameter.

During the latter part of 1919, the practice of seeding the granulated pans was instituted with very satisfactory results. The term "seeding," however, is rather a misnomer. Contrary to the practice of seeding as used in the manufacture of raw sugar by actually building up the grain introduced into the pans, the refinery practice consists merely of concentrating the liquor to the point approximating supersaturation and then drawing in a quantity of sugar dust ranging from a pint to a couple of gallons.

The quantity of sugar drawn in would seem to have little bearing upon the quantity appearing in the proof, nor does the quality of the introduced sugar appear to have the influence that might be expected upon first thought, in that results have been obtained with the coarser grades of sugar, as "seed," as well as with the fine dust. Insufficient work has been done in the way of investigation so far to be able to state definitely just what the action is and what laws are followed, but from my more or less superficial observations I am forced, for the present, to an adoption of a theory that the pan graining is due to a shock from the sudden introduction of dry sugar into a liquor already supersaturated, and not to an actual building up of the introduced grain. The benefit derived from this practice is observed in the evener grain appearing in the pan, due to its more rapid formation.

The satisfactory production of yellow *Soft Sugars* depends upon the presence of a maximum of glucose in the pan syrup, the proper depth of color, minimum of ash, minimum of iron organates, a fine grain, and a minimum pan temperature. To meet these conditions, syrup derivatives of affination syrup are used after a maximum of char-filtration, these syrups in one case consisting of the swing-off from the white granulated, boiled from the poorest liquor (No. 4), for the darker grade of softs, and a higher purity affination derivative for the lighter grade.

The soft sugars are, as you all know, the brown sugars of candy-making days, and are actually soft to the touch. On this Coast the two American refineries manufacture only three grades, Extra C, Golden C, and Yellow D, grading downward in color from a pale yellow to a rather dark yellowish-brown, respectively. In the East the market is much greater for such sugars, the refineries there beginning with a snow-white soft sugar, and grading down gradually through 15 products to the lowest, somewhat darker than our Yellow D. Our task in the West, then, is obviously much more exacting than what the Easterners have to contend with. Here we must use extreme care to get the exact shade of color at all times, whereas, in the Atlantic refineries, practically any shade of soft sugar that is produced will fit into some one of the 15 different grades.

Soft sugars, then, are crystallized sugars the same as granulated sugar, but with a definite amount of the mother-liquor, from which it was crystallized, retained on the surface of the crystals, the result being to make the marketed sugar always slightly moist.

But the soft sugars are distinctive from granulated sugar in another way also, in a way that gives it the distinctive soft texture. Comparative inspection of a white Berry sugar and a soft sugar under the microscope will show a very striking difference indeed. The Berry sugar crystals will be seen to be sharply cut and distinct, and this sugar, if it had the same amount of mother-liquor adhering to it as the soft sugar, would still feel hard and sharp to the touch. The soft sugar crystals, on the other hand, will be noted, under the glass, to be cemented together in minute bunches—conglomerate grain. Under the influence of a minimum temperature (at which softs are boiled, in contrast to the relatively high temperature at which white granulated sugars are boiled), the minute crystals first form, and then cement themselves together. When lightly pressed in the hand, this conglomerate crushes apart, giving the sensation of softness. One pan, 10 feet in diameter, of the calandria type, is used for this work.

To sum up—our refined output consists of the following products:

(1) Cubes and half-cubes—Packed principally in barrels, half barrels and boxes.

(2) Cubelets—Packed principally in barrels, half barrels, boxes and solid-packed cartons.

(3) Con A—Packed principally in barrels, half barrels, and bags.

(4) Con AA—Packed principally in barrels, half barrels, and bags.

(5) Berry granulated—Packed principally in barrels, half barrels, and bags.

(6) Standard granulated—Packed principally in barrels, half barrels, and bags.

(7) Coarse granulated—Packed principally in barrels, half barrels, and bags.

(8) Powdered (from milled granulated)—Packed principally in boxes, barrels, and some bags.

(9) Bar (from milled granulated)—Packed principally in boxes, barrels, and some bags.

(10) Extra C—Soft sugar, packed principally in bags and boxes.

(11) Golden C—Soft sugar, packed principally in bags and boxes.

(12) Yellow D—Soft sugar, packed principally in bags and boxes.

Under the present scheme of operation, our remelt sugar system is divided into two parts—in other words, we produce two sets of remelt sugar, three grades in each set. The first set, which we term our Regular Remelts, originates entirely from the boiled down syrups from the granulated and soft sugar pans; the second set, termed concentrated Sweet-Water Remelts, originates from the evaporated Char Sweet-Water and other sweet-waters from various parts of the plant. We have, then, No. 1, No. 2, and No. 3 Regular Remelts, and No. 1, No. 2, and No. 3 Sweet-Water Remelts; the No. 2 and No. 3 massecuite, in each case, passing through crystallizers before being purged. The object of the double system has been to keep products of essentially different non-sugar constitution separated, although the apparent purities of each set are kept approximately the same, as follows:

No. 1	Remelt	Massecuite	.... 78° to 80° purity
No. 2	"	"	.... 70° to 72° "
No. 3	"	"	.... 64° to 66° "

All remelt sugars are sent back over the char.

In concluding the description of the boiling system, it may be of interest to you for me to state that, of all the massecuite boiled in the plant, about 88.5% is white sugar massecuite, 4.2% soft sugar massecuite, and 7.3% is remelt massecuite. The output during the last month (March) was about 1375 tons of white sugar and 63 tons softs per day. It is thought that with an ample supply of raws we will be able to maintain, with our present equipment, an output of about 1600 or 1700 tons per day, and that the plant in 1921 will have a capacity of at least 2000 tons output.

The final molasses, or "black-strap," from the No. 3 massecuite, has an apparent purity, high according to your standards, of 40° to 44°. It is this molasses which will eventually have to be used as the base for barrel syrup, if the trade should call for it, and it is expected that this will resolve itself into a very difficult matter owing to the high ratio of ash to the other non-sugars of the Hawaiian raws. At the present time, our entire output of molasses, some 15,000 or 20,000 tons per annum, is sold for the purpose of fermentation and distillation into alcohol. The extreme aridity of the U. S. A. has, however, eliminated any possibility of "profiteering" through this means, so it is obvious that a very important question before us at the present time is, "How can we best dispose of our molasses?"

This is the story, very superficial indeed, of the refining of sugar. The intricacies of char-house practice; the manifold details of refinery control; the description of the great power plant; the story of the many intensely interesting technical investigations, current and completed; the study of the warehousing and marketing of the product,—each of these could be talked about to a very much greater length than this long paper has already run, and it is only illustrative of the enormous detail in the practice of refining. Some parts of it are so complicated, so deep, so very difficult to fathom, that I sometimes think we have fields ahead of us so vast as to make it seem possible that the next few decades will reveal to us more than all past history has so far taught us.

The latter seems to have foundation in the fact that at last the individual refiner is beginning to abandon his self-sufficiency, and is beginning to realize that a fair exchange of views and friendly treatment and relationship cannot but be instrumental in promotion and advancement of the industry as a whole and to each one in particular.

The refining industry today recalls the days of secrecy surrounding the art of sugar-boiling. There are those here who no doubt remember the profound mystery that surrounded the old-time sugar-boiler, who fostered the mystery by prohibiting everyone, even the superintendent, from putting his foot on the pan floor while he was engaged in operating the pan. This custom, however, was a product of the suspicion and jealousy of the Old World and did not appeal to the American spirit of initiative and demand for progress. When, then, the American woke up to the fact that this was no mystery at all, that it was not the practice of magic, and that there was nothing in the sugar business, any more than in any other human venture, that could not be improved upon, the old-time sugar-boiler-mystic passed on quickly and completely.

And thus, also, will the secrecy of sugar refining gradually give place to a more enlightened policy. It is indeed gratifying to be associated with an institution such as the California and Hawaiian Sugar Refining Co., which, developed by men bred and trained in the atmosphere of the broad-minded West, is opening the doors of its refinery to the world and spreading its records for the inspection of all eyes. Such policy is contagious, I am sure, and this is evidenced by the appearance of a more liberal policy in the practice of other refineries also. No doubt, the policy of the closed door will soon be a matter of the past.

And now our management has given further evidence of its clear vision by sending us here to open our eyes to the fact that there is more to our family than just little old Crockett, and for us to realize that it is not *our* refinery so much as it is *yours*. We came as strangers to your lovely land, have been warmed by your great hospitality, and will surely leave again with regrets, and with the hope that we may soon be privileged to reciprocate in some slight degree at least. We hope that we may be honored by your pride in our establishment and accomplishments in Crockett, as we are quickly learning to take pride in yours here.

We have seen your "Liquid Sunshine," the great helper to give what some poetic soul has termed your "Crystallized Sunshine." May we not urge you to visit us in California that we may demonstrate our methods of producing that which we might (at the risk of overdoing the simile) call "Filtered Sunshine"?

Fertilization at Pepeekeo for Three Successive Crops.

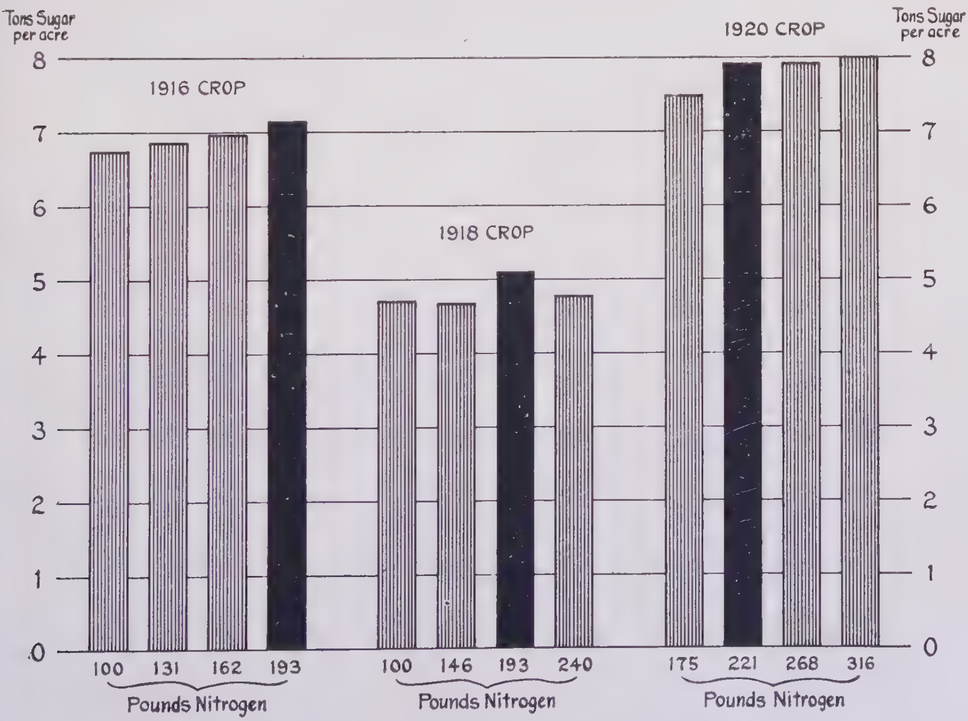
Pepeekeo Experiment No. 2, 1916, 1918 and 1920 Crops.

This experiment was laid out in 1915 by Mr. L. D. Larsen, and with slight modifications has been carried through three successive crops.

The cane involved was Yellow Caledonia, second ratoons for the 1916 crop. For the 1916 crop the experiment consisted of 13 plots, each 1/6 acre in size. In 1914 all plots received a uniform application of 1,000 pounds per acre of complete fertilizer, containing 10% nitrogen, 7% phosphoric acid and 4½% potash. The 4 X plots received no further fertilization, the 3 A plots received 200 pounds of nitrate of soda per acre in one dose during the second season, the 3 B plots received 400 pounds in two equal doses, while the 3 C plots received 600 pounds of nitrate in three equal doses.

For the 1918 and 1920 crops eleven more plots of the same size as the original ones were added to the experiment, making twenty-four plots in all, and the nitrate of soda applications to the A, B and C plots were changed to 300, 600 and 900 pounds per acre, in one, two and three doses, respectively, in 1918. For the 1920 crop the B and C plots received the nitrate in two equal doses. The

FERTILIZER RESULTS FROM THREE SUCCESSIVE CROPS.
PEPEEKEO SUGAR CO. EXP. 2, 1916, 1918 & 1920 CROPS
The solid black column represents about the economic limit in amounts of nitrogen to apply.



1918 crop received 100 pounds of nitrogen per acre during the first season. For 1920 crop this amount was increased to 175 pounds of nitrogen during the first season.

The results of the three harvests are given in the following tables:

1916 CROP — YELLOW CALEDONIA, SECOND RATOONS.

No. of Plots	Treatment		Total Lbs. of Nitrogen	Yield per Acre		
	First Season	Second Season		Cane	Q. R.	Sugar
4 X	100 lbs. Nitrogen	....	100	52.3	7.75	6.75
3 A	100 lbs. Nitrogen	200 lbs. N. S. (31 lbs. N.)	131	56.3	8.20	6.87
3 B	100 lbs. Nitrogen	400 lbs. N. S. (62 lbs. N.)	162	58.5	8.38	6.98
3 C	100 lbs. Nitrogen	600 lbs. N. S. (93 lbs. N.)	193	60.7	8.48	7.16

Reported in detail in Record Vol. XIV, page 299.

1918 CROP — YELLOW CALEDONIA, THIRD RATOONS

No. of Plots	Treatment		Total Lbs. of Nitrogen	Yield per Acre		
	First Season	Second Season		Cane	Q. R.	Sugar
6 X	100 lbs. Nitrogen	....	100	39.6	8.39	4.72
6 A	100 lbs. Nitrogen	300 lbs. N. S. (46 lbs. N.)	146	39.0	8.32	4.68
6 B	100 lbs. Nitrogen	600 lbs. N. S. (93 lbs. N.)	193	42.4	8.21	5.12
6 C	100 lbs. Nitrogen	900 lbs. N. S. (140 lbs. N.)	240	42.4	8.84	4.79

1920 CROP — YELLOW CALEDONIA, FOURTH RATOONS.

No. of Plots	Treatment		Total Lbs. of Nitrogen	Yield per Acre		
	First Season	Second Season		Cane	Q. R.	Sugar
6 X	175 lbs. Nitrogen	....	175	55.6	7.42	7.50
6 A	175 lbs. Nitrogen	300 lbs. N. S. (46 lbs. N.)	221	59.5	7.52	7.94
6 B	175 lbs. Nitrogen	600 lbs. N. S. (93 lbs. N.)	268	60.9	7.68	7.94
6 C	175 lbs. Nitrogen	900 lbs. N. S. (140 lbs. N.)	315	63.2	7.88	8.01

NOTE: In second season fertilization the A plots received the nitrate in one dose, the B plots in two equal doses, and the C plots in three equal doses in 1916 and 1918, and two equal doses in 1920.

The results of these three harvests are fairly consistent, and, for the conditions involved, indicate the profitable limits of fertilization to be about 200 pounds of nitrogen per acre.

In the first crop, increases in yield were obtained to the limit of fertilizer application, which was 193 pounds of nitrogen; in the second crop no increase in yield was obtained when increasing the nitrogen from 193 pounds to 240 pounds per acre, while in the third crop no increase was obtained above 222 pounds of nitrogen.

Details of Experiment.

Second Season Fertilization—Amount to Apply.

Object:

1. To determine the profitable limit of second season fertilization.
2. To note the effect continuous heavy applications of nitrate of soda may have on the soil.

Location:

Pepeekeo Sugar Co. field 17, on plantation road 42 lines from Government road.

Crop:

Yellow Caledonia, 4th ratoons, long.

Layout:

Number of plots: 24.

Size of plots: 1/6 acre, consisting of 6 rows, 5.55 ft. wide and 216 ft. long.

Plan:

Fertilization: First season, uniform with adjoining field.

Second season:

POUNDS NITRATE OF SODA PER ACRE

1916 CROP

Plots	Plot Numbers	April 1, 1915	May 15, 1915	July 1, 1915	Total
X	1, 5, 9, 13	....	....	....	....
A	2, 6, 10	200	....	....	200
B	3, 7, 11	200	200	....	400
C	4, 8, 12	200	200	200	600

1918 CROP

Plots	Plot Numbers	March 29, 1917	May 31, 1917	July 25, 1917	Total
X	1, 5, 9, 13, 17, 21	....	....	....	....
A	2, 6, 10, 14, 18, 22	300	....	....	300
B	3, 7, 11, 15, 19, 23	300	300	....	600
C	4, 8, 12, 16, 20, 24	300	300	300	900

1920 CROP

Plots	Plot Numbers	March 1, 1919	May 15, 1919	Total
X	1, 5, 9, 13, 17, 21	....	....	....
A	2, 6, 10, 14, 18, 22	300	....	300
B	3, 7, 11, 15, 19, 23	300	300	600
C	4, 8, 12, 16, 20, 24	450	450	900

J. A. V.

A Sugar Cane Cancer-root.

Aeginetia indica Roxb.

The accompanying photographs show groups of a curious little flowering plant which is parasitic on the roots of sugar cane in the Philippine Islands. This plant belongs to a family, the components of which have abandoned the use of chlorophyll, and steal their food from other plants by attaching themselves to the roots of their hosts and drawing food materials directly from their tissues. Being devoid of chlorophyll they are never green, but appear white, yellowish or brown, depending upon their age and condition. A few species are characteristically pink and red.

SUGAR CANE CANCER-ROOT, *AEGINETIA INDICA* ROXB.

As a rule, plants of this family are rather scarce in nature, but this particular species is said to be of frequent occurrence in cane fields in the Philippines, and in some cases cause serious damage. The plant body consists of a short, almost leafless and colorless stem which remains nearly or quite buried in the soil in close contact with the cane roots. From this stem there springs one to three long slender flower stalks, each bearing a single nodding flower which eventually yields a seed capsule containing many seeds.

Unless this plant has habits not shared by its American congeners, it should be possible to eradicate it by the judicious use of the hoe. If the plants are not permitted to flower and seed they should entirely disappear from the fields within a few years.

The photographs of this interesting plant, which we reproduce herewith, were supplied by Mr. C. R. Hemenway. H. L. L.

SUGAR CANE CANCER-ROOT, *AEGINETIA INDICA* ROXB.

Badila Gives the Best Yield at Kilauea.

Kilauea Experiment No. 19, 1920 Crop.

This was a test comparing Badila, Yellow Caledonia and D 1135. The cane involved was plant, in a mauka, non-irrigated field. The cane was 19½ months old when harvested, having been planted May 20, 1918, and harvested January 6, 1920. The experiment consisted of 48 plots, each 1/10 acre in area.

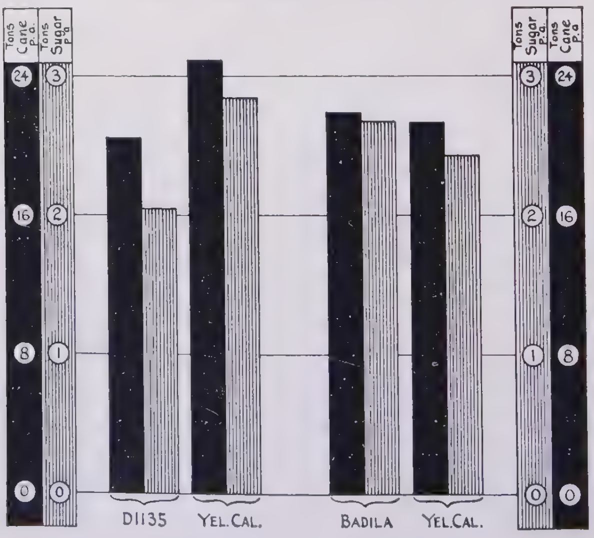
The results of the harvest were as follows:

Number of Plots.	Variety.	Yield per Acre.			Gain or Loss over Y. C. Checks.	
		Cane.	Q. R.	Sugar.	Cane.	Sugar.
Twelve	D 1135	20.5	9.98	2.05	— 4.7	— 0.82
Twelve	Yellow Cal.	25.2	8.78	2.87		
Twelve	Badila	21.9	8.20	2.67	+ 0.8	+ 0.27
Twelve	Yellow Cal.	21.1	8.78	2.40		

In this test D 1135 proved to be distinctly inferior to either Yellow Caledonia or Badila, producing less cane per acre, containing a much poorer juice.

The Badila and Yellow Caledonia produced about the same amount of cane per acre, but the Badila juice was better, thereby leading the Yellow Caledonia by 0.27 ton of sugar per acre.

VARIETY TEST
GRAPH SHOWING THE COMPARATIVE YIELDS OF YELLOW CALEDONIA, BADILA AND D1135.
KILAUEA SUGAR PLANTATION CO. EXP. #19, 1920 CROP



VARIETY TEST

Map Showing The Yields By Plots Of Yellow Caledonia, Badila, And D1135.

Kilauea Sugar Plantation Co. Exp.*19, 1920 Crop

First Ratoons

Mauka

3' Path

37 D1135 20.26	38 Y. C. 26.12	39 D1135 16.75	40 Y. C. 23.32	41 D1135 18.76	42 Y. C. 23.64	43 Badila 22.86	44 Y. C. 18.31	45 Badila 19.72	46 Y. C. 15.37	47 Badila 19.05	48 Y. C. 16.67
25 Y. C. 25.38	26 D1135 24.00	27 Y. C. 25.56	28 D1135 18.91	29 Y. C. 24.06	30 D1135 17.99	31 Y. C. 22.53	32 Badila 21.49	33 Y. C. 23.34	34 Badila 20.41	35 Y. C. 18.04	36 Badila 19.35
13 D1135 24.68	14 Y. C. 27.03	15 D1135 22.90	16 Y. C. 22.95	17 D1135 16.73	18 Y. C. 22.40	19 Badila 21.81	20 Y. C. 21.93	21 Badila 26.39	22 Y. C. 22.62	23 Badila 24.37	24 Y. C. 21.49
1 Y. C. Discard	2 D1135 22.02	3 Y. C. 31.37	4 D1135 22.91	5 Y. C. 25.67	6 D1135 19.74	7 Y. C. 23.81	8 Badila 19.94	9 Y. C. 23.65	10 Badila 26.25	11 Y. C. 25.35	12 Badila 21.09

3' Path

Tons Cane p.a.

Summary Of Results

No. of Plots	Variety	Yields Per Acre		
		Cane	Q.R.	Sugar
12	D1135	20.5	9.98	2.05
12	Yellow Caledonia	25.2	8.78	2.87
12	Badila	21.9	8.20	2.67
12	Yellow Caledonia	21.1	8.78	2.40

In planting, Badila body seed was used and spaced 5 inches. The Yellow Caledonia was from good top seed planted end to end, while the D 1135 had both top and body seed, planted end to end. The Caledonia came up to a better stand, and closed in before either of the other two, the Badila being a poor third at that time. Notes made on April 24, 1919, place Yellow Caledonia first, D 1135 second, and Badila third, while on June 16, 1919, Badila was placed first, "because, generally, it has controlled weeds better, and appears to have suffered less from drought."

In harvesting this experiment Mr. Thurston states that he could not find a single stick of Badila damaged by rats,[1] while Yellow Caledonia and D 1135 were quite badly rat-eaten; on the other hand borer infestation was very much heavier in the Badila than in either of the other varieties.

---

1 As against this, some Badila just harvested at Waipio was very badly rat-eaten, much more so than adjoining Caledonia.

DETAILS OF EXPERIMENT.

Object:
To test the comparative value of the following varieties: Badila, D 1135 and Yellow Caledonia.

Location:
Field 25.

Crop:
Plant Cane.

Layout:
Number of plots, 48.
Size of plots, 1/10 acre (54'x80.7'), each plot consisting of 12 straight lines (4.5'x80.7').

Plan:

Variety.	No. Plots.	Plot Numbers.											
Badila	12	8	10	12	19	21	23	32	34	36	43	45	47
D 1135	12	2	4	6	13	15	17	26	28	30	37	39	41
Yellow Caledonia	24	1	3	5	7	9	11	14	16	18	20	22	24
		25	27	29	31	33	35	38	40	42	44	46	48

Fertilization uniform by plantation
Experiment planned by J. A. Verret and G. B. Grant.
Experiment laid out by G. B. Grant.
Experiment harvested by R. S. Thurston.

[J. A. V.]

Preventing Boiler Explosions.*

By C. S. TOMPKINS.

From a study of boiler explosions, which are of much too frequent occurrence, it is apparent that boiler inspectors are often tempted to allow too high working pressures, with the result that property and lives of the engineers, as well as other employees, are unnecessarily exposed to danger.

An example of this practice is the boiler of a Minneapolis laundry, which exploded several months ago. The boiler in question was of the return tubular type, 66 in. in diameter by 18 ft. in length. The shell steel was 7/16 in. thick, with a tensile strength of 55,000 lbs. The longitudinal seams were triple-riveted butt joint construction, but, on account of having been damaged, the lower half of the sheet, directly over the fire, had subsequently been replaced by what is known as a half-sheet patch. The longitudinal seams employed in making this repair were of the double-riveted lap joint construction, and located below the hangers by which the boiler was suspended. The joints were thus exposed somewhat to the heat of the fire.

The boiler, which, according to the insurance company's records, was 15 years old, was inspected regularly by the insurance underwriter's inspector, and was therefore exempted by the Minnesota State laws from State inspection. The insurance inspector allowed a maximum safe working pressure of 110 lbs.

* Reprinted from Power Plant Engineering, May 1, 1920.

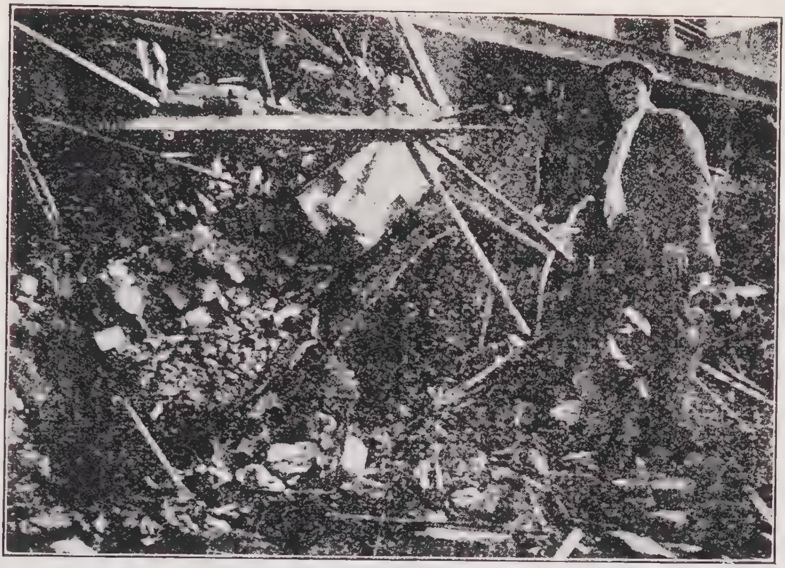


Fig. 1.
Destruction caused by typical boiler explosion.

Fig. 2.
The top edge shows what was left of a double riveted lap joint used in putting on a patch.

The first step in the investigation was to test the safety valve, which was found to release at 110 lbs. Within 2 minutes prior to the explosion, the safety valve was known to have blown. The force of the explosion was sufficient to move the boiler 50 ft. from its setting and force it through a 3-ft. stone wall. A part of the boiler front was thrown nearly a city block. Figure 1 shows the boiler end projecting through the stone wall. Figure 2 shows one of the points of failure, the man's right hand touching the original triple-riveted joint, and his left touching the remains of the lap joint.

Paragraph 187 of the Boiler Code of the American Society of Mechanical Engineers, which is standard in Minnesota, reads as follows: The riveted longitudinal joints of a shell, or drum, which exceeds 36 in. in diameter, shall be of butt and double strap construction. This does not apply to the portion of a boiler shell which is staybolted to the firebox sheet.

Paragraph 188 reads: The longitudinal joints of a shell, or drum, which does not exceed 36 in. in diameter may be of lap riveted construction, but the maximum allowable pressure shall not exceed 100 lbs. per square inch.

Paragraph 189 reads: The longitudinal joints of a horizontal return tubular boiler shall be located above the fire line of the setting.

It will be seen that the inspector who allowed 110 lbs. in the example given was very liberal. A factor of safety of five would give a working pressure of 105 lbs., and a further allowance should have been made for the patch. Paragraph 188 absolutely forbids more than 100 lbs. working pressure.

All engineers' organizations ought to insist upon the adoption of the Boiler Code of the American Society of Mechanical Engineers, and a strict adherence thereto by inspectors. This would eliminate to a great extent the large number of boiler explosions which occur annually. [W. E. S.]

Plantation Apprentices.

By Donald S. Bowman.

Industrial Service Bureau, H. S. P. A.

It would seem from a study of the rural school population that the male youth of the plantations would more than furnish all of the skilled and semi-skilled labor demanded. That the plantation-raised boys drift away from their homes, largely owing to the fact that they see no future on the plantations, is realized by those who have given the subject consideration.

Much has been done on the mainland in the big industrial centers along the lines of vocational guidance, and it has been advocated that this subject be developed as a branch of our educational system.

Vocational guidance means helping the boy and his parents to consider his future occupation, and helping them decide what he is best fitted for in life and to take the necessary steps leading to his being properly placed where he may obtain the necessary training.

This work should be undertaken by someone connected with the plantation, as it is necessary to do considerable work with both the boy and his parents in order that their interest and ambitions may be aroused. Full information should be at hand as to the various employments open to apprentices on the plantation and these facts presented to the most promising boys. It should be made plain to them that such work will be a real vocation with a future, instead of a job. This information should consist of the following:

1st: The qualifications necessary to become an apprentice, listing the skilled and semi-skilled occupations.

2d: The action to be taken in applying.

3d: The length of service as an apprentice, and rate of pay.

4th: Average pay of occupation, and other benefits.

Suggestions.

The educational campaign should be handled by the Industrial Service Inspector working directly under the Plantation Manager.

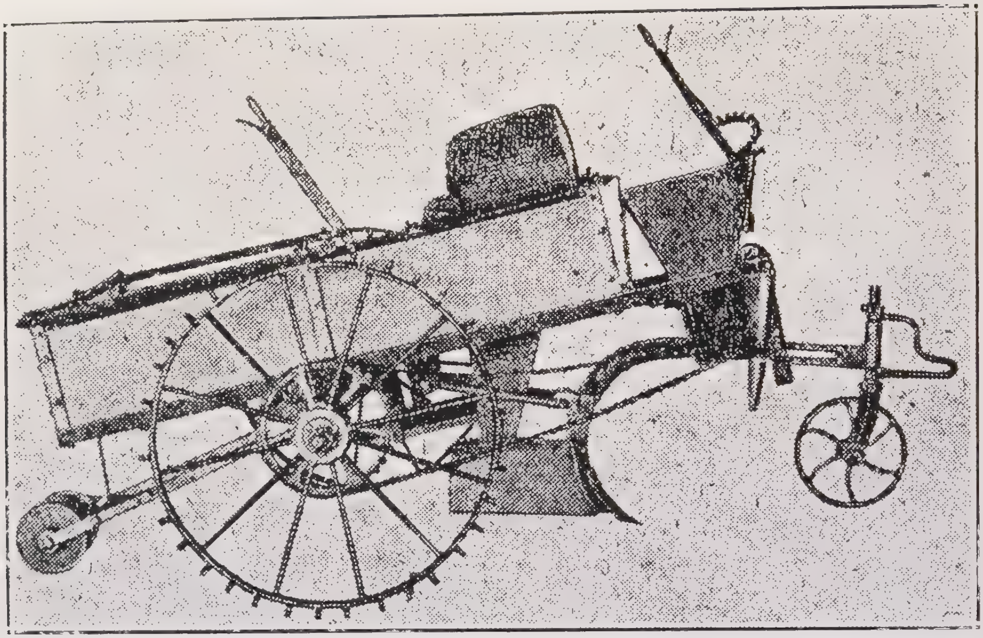
That the interested boys in the last two grades of the public school be formed into a class where they will be taught Americanism and the advantages offered on the plantation in the different skilled and semi-skilled trades.

The Inspector's work in connection with vocational guidance would include advice and direction, he to serve as a means of communication between the plantation management and applicants for apprenticeships, to collect required information as to the trades and the qualifications necessary, to make this and other information available through classes conducted for that purpose, to assist pupils by laying out any necessary courses of study after they have become apprentices. After boys have been placed, and at least during their probation period, the Inspector should keep in close touch with them, offering advice, etc., and if a boy is found to be ill-fitted for the work, help him to select some other occupation.

The suggested trades and semi-skilled trades that could be filled by the apprentice system without special education, taking the boys who have finished the eighth grade, would include:

Steam Engineer	Truck and Tractor Operator
Pump Engineer	Painter
Gas Engine Engineer	Carpenter
Machinist	Irrigation Worker
Blacksmith	Stone Mason and Concrete Worker
Sugar Boiler	Electrician's Assistant
Steam Plow Operator	

It is apparent that many advantages will accrue through the development of the boys born and raised on the plantation, but it is essential that the plantation, to obtain such desired results, should take an active interest.



A Machine for Cane Planting.

From a correspondent in Australia we publish the following account of the cane planting machines in use there:

"There are many types of cane planters used throughout Queensland. The one most commonly adopted is a box mounted upon wheels capable of holding about 1½ to 2 cwt. of cut plants, plants being cut into lengths containing 3 'eyes.' This box has handles attached and a seat in the box for a boy to sit. At the end nearest the driver is an iron tube. Underneath on each side of the tube are two flat iron plates coming to a point in front of the tube. One horse is attached to the machine.

"The drills are opened by a drill or double moldboard plow and the planter is then brought into the drill. As the machine is driven up the drill the boy drops his plants through the tube and the iron plates throw on the soil to cover them. Planting can be carried out more rapidly than by hand. Some four acres a day can be covered by the driver and boy. The planting, of course, is not done so carefully, as the plants fall in any position, and not with the eyes at the side, but the strike is satisfactory if the boy drops the plants regularly and not too fast. It is in common use in most of the sugar districts of Queensland, and has the advantage of putting the plants well down into the moisture during dry spells. Its use is considered much more economical than hand planting.

"Other types are patented and in use. Some of these are drays with the covering part hung underneath, so that a great many more plants may be carried to the field. They, however, require more horse power. The attached cut shows a patent of Willmans.

"Most farmers, however, make their own planters, or obtain the small machine first described." [W. P. A.]

Factory Results in Java, 1919.*

	Defecation Factories	Sulfitation Factories	Carbonation Factories	General Average
Cane:				
Polarization	12.15	12.49	12.84	12.38
Fiber	12.98	13.06	12.99	13.01
Bagasse:				
Polarization	4.04	3.95	4.06	4.01
Moisture	47.11	47.02	46.64	47.01
Fiber	47.43	47.79	47.79	47.62
Mixed Juice:				
Brix	15.29	15.68	16.02	15.54
Polarization	12.56	12.99	13.36	12.83
Sucrose	12.75	13.13	13.51	13.00
Gravity Purity	83.3	83.8	84.3	83.7
Glucose	1.13	1.11	1.03	1.11
Weight per 100 Cane	87.82	87.52	87.48	87.66
Press Cake:				
Polarization	5.25	5.38	0.79	3.79
Weight per 100 Cane	1.74	2.02	5.98	2.42
Syrup:				
Brix	55.77	53.87	55.02	54.95
Polarization	47.10	45.96	47.43	46.70
Sucrose	47.57	46.21	48.05	47.13
Gravity Purity	85.3	85.8	87.3	85.8
First Massecuites:				
Brix	91.94	92.32	92.79	92.25
Apparent Purity	84.0	84.2	84.7	84.2
Second Massecuites:				
Brix	92.97	93.44	93.68	93.22
Apparent Purity	77.6	77.1	76.4	77.3
Third Massecuites:				
Brix	94.52	94.72	95.23	94.67
Apparent Purity	69.0	69.1	70.3	69.2
Fourth Massecuites:				
Brix	99.96	97.79	96.98	97.29
Apparent Purity	59.4	59.8	57.4	59.3
Molasses Purities:				
First	64.5	65.1	65.8	65.0
Second	57.5	56.7	55.5	57.0
Third	49.5	48.4	47.2	48.9
Sugars:				
White Plantation:				
Polarization	....	99.61	99.59	99.61
Per cent of total sugars	....	36.29	13.59	49.88

* From Annual Synopsis of Mill Data, Experiment Station of the Java-Suikerindustrie, averages from 142 Javan factories.

FACTORY RESULTS IN JAVA (Continued).

	Defecation Factories	Sulfitation Factories	Carbonation Factories	General Average
Sugars (Continued):				
No. 16–20 D. S.:				
Polarization	98.42	....	....	98.42
Per cent of total sugars	23.19	....	....	23.19
No. 14 D. S.:				
Polarization	97.33	....	....	97.33
Per cent of total sugars	23.38	....	....	23.38
Second Sugars:				
Polarization	....	98.39	98.27	98.34
Per cent of total sugars	....	1.09	0.92	2.01
Molasses Sugars:				
Polarization	85.76	86.91	87.81	86.48
Per cent of total sugars	0.52	0.34	0.17	1.03
Black Stroop:				
Polarization	81.88	81.57	83.36	82.15
Per cent of total sugars	0.23	0.15	0.13	0.51
Final Molasses:				
Brix	91.93	93.02	91.67	92.34
Sucrose	33.62	33.32	32.74	33.39
Gravity Purity	36.6	35.8	35.7	36.2
Glucose	27.65	28.39	25.76	27.65
Ash	9.96	9.59	9.22	9.72

[R. S. N.]

Analyses of Cuban Sugars.*

Results for Nineteen Years as Observed at One Refinery.

By W. D. Horne, Ph. D.

In the accompanying table is given a set of average analyses of Cuban centrifugal sugars received during the past nineteen years at one of the Atlantic seaboard refineries. A careful study of these analyses shows that for the past few years the Cuban sugars of this class have averaged a little above 95.5 polarization, about 0.6 per cent ash, about 1.3 per cent glucose, and a trifle less organic matter. The moisture content has been a little more than 1.1 per cent.

Good Quality Maintained.

These figures are fairly satisfactory, indicating the composition of a sugar which keeps well in storage and which can be refined with satisfactory results. It is particularly gratifying to note that in the effort to produce vast quantities of sugar Cuba is, as a rule, maintaining a satisfactory quality in the product. Refiners are becoming more discriminating in regard to the refining character of the sugars purchased and are closely watching the individual marks, with the result that those estates producing sugars most advantageous for refining have the greater demand for their output.

* Facts About Sugar, March 20, 1920.

AVERAGE ANALYSES OF CUBAN CENTRIFUGAL SUGARS.

Year.	Polarization	Glucose.	Water.	Ash.	Organic Matter.
1901	94.00	1.88	1.74	0.50	1.88
1902	94.36	1.75	1.43	0.58	1.86
1903	95.09	1.22	1.59	0.51	1.59
1904	94.37	1.57	1.47	0.56	2.03
1905	95.00	1.45	1.37	0.60	1.58
1906	94.76	1.39	1.43	0.67	1.75
1907	95.02	1.21	1.39	0.67	1.71
1908	94.97	1.15	1.20	0.69	1.99
1909	95.31	1.26	1.21	0.59	1.65
1910	95.23	1.22	1.33	0.66	1.56
1911	95.57	1.18	1.18	0.68	1.39
1912	95.65	1.28	1.13	0.58	1.36
1913	95.48	1.28	1.30	0.60	1.34
1914	95.79	1.20	1.10	0.61	1.30
1915	95.89	1.31	1.02	0.56	1.22
1916	95.52	1.47	1.10	0.67	1.24
1917	95.80	1.27	1.13	0.54	1.26
1918	95.43	1.28	1.32	0.58	1.39
1919	95.64	1.37	1.15	0.57	1.27

[R. S. N.]

Sugar Industry of Philippine Islands.*

By J. F. Boomer.

The growing of sugar cane and the manufacture of commercial sugar are two phases of an industry in the Philippine Islands which should be of great interest to American manufacturers. While the growing of cane is purely an agricultural question, it has come into great prominence in latter years, since modern agricultural machinery has become more and more a factor in the sugar industry. Up to date, however, capital has been more profitably employed in the manufacture of commercial sugar, and at the present time more inviting opportunities are offered in this field than are held out in the sale of agricultural machinery. The manufacture of centrifugal sugar requires large investment, and while a few individual planters have established small mills on their holdings and in some instances groups of planters have banded together for the establishment of larger mills, the tendency in the islands is toward the separation of the agricultural from the manufacturing branch of the sugar industry. This has led to a demand for outside capital in order to supply the necessary equipment for the manufacturing end.

*In Commerce Reports, October 23, 1919.

For many years the average planter of the Philippines was content with the old-style methods and the consumer of Philippine sugar was satisfied with the muscovado and pilon product of these methods, but this time has passed and every up-to-date planter is now convinced that it would be vastly to his advantage to have his cane made into centrifugal sugar and is ready to cooperate in the establishment of a central in his neighborhood by entering into the usual contract for the delivery of his cane to the factory.

Larger Profits Made on Centrifugal Sugar.

During the past year 18 modern mills produced for export 64,018 metric tons of centrifugal sugar, as against 47,224 tons exported in 1917, at an average price for 1918 of $91.60 per ton. During the same year 209,240 tons of muscovado sugar were exported, compared with 158,685 tons for 1917, at an average price of $42.60 per ton for 1918.

Heretofore the planters have made a fair profit on muscovado sugar when their product has been up to grade, but where the product has been inferior the prices obtained have hardly paid the cost of production. It is estimated that the cost of producing the cane for a picul (137.5 pounds) of sugar is $1, whereas the cost of manufacturing the cane into sugar by the old methods, furnishing sacks, and otherwise preparing the product for market is placed at 50 cents. The cost of shipping to market, allowing for insurance and depreciation, added to this, brings the estimated cost of a picul of muscovado or pilon sugar up to $2, and when it is remembered that the three-roller mill employed leaves approximately 50 per cent of the juice in the cane, it will be seen that the cost to manufacture centrifugal sugar, even by contract, is practically no more than the cost to make muscovado or pilon sugar, whereas the prices obtained for the former are double those obtained for the latter. This difference in price and the further fact that the cost of producing muscovado sugar has advanced more quickly than its market price form the convincing argument that has turned the thoughts of sugar planters to the central. Moreover, the Chinese market for muscovado sugar has been waning in recent years, and a preference has been shown there for Philippine centrifugal sugar of 96° polarization.

Market for Small Mills—Transportation of Cane and Sugar.

One enterprising manufacturer of sugar machinery, who recently opened an office in Manila, has sent his experts to the islands to study the needs of the field and is adapting his machinery, which was designed primarily for other sugar-growing countries, to meet the requirements of the Philippine market. It is probable that there will continue to be a market in the Philippines for small centrifugal mills of from 500 to 1,000 tons daily capacity. This type of mill appears to be best suited in point of cost and availability to the large plantation owner who desires to mill his own crop and, perhaps, that of his neighbor.

A tendency is to be noted on the part of the planters in some neighborhoods to unite in the purchase of a mill to be as centrally located as possible. The land in some sections of the sugar regions, however, is divided into such small holdings that the only feasible way to give these smaller planters the advantages of the modern mill is through the large central, with its contract system and provisions for transportation.

The Manila Railroad's published rates for transporting a ton of cane are as follows: Fifty kilometers (a kilometer equals approximately five-eighths of a mile), $0.625; 100 kilometers, $0.93; and 150 kilometers, $1.155. During the greater part of the past two years it has been impractical to undertake to haul cane great distances, owing to the congested traffic on the Manila Railroad lines. This company has been short of rolling stock to meet the increasing demands made upon it, and the war conditions abroad made it impossible to procure any equipment. The delays in the transportation of cane have caused a marked decline in its milling value, as four days are regarded as the maximum time that should elapse between the cutting and the milling of the cane.

The general rates quoted by the Manila Railroad Company for the transportation of sugar are as follows: Fifty kilometers, $1.54 per ton; 100 kilometers, $2.12; and 150 kilometers, $2.57. There is no difference in the freight charged for centrifugal sugar and that charged for muscovado sugar. At times during the past year interisland steamship rates on sugar have been $2.75 per ton, although it is difficult to give definite quotations, and ocean rates to the United States about $30 per short ton.

Labor Required for Sugar Central.

A large sugar central should have an office force consisting of a superintendent, who is generally paid from $3,000 to $4,000 per year; an assistant superintendent, $2,000 to $4,000; a chief chemist, $2,000 to $3,000; and four assistant chemists (usually Filipinos), $50 per month. The ordinary labor required during the milling season is a night and day shift, each of 50 to 75 men. It is generally considered that 50 laborers are sufficient for a mill with a capacity of 800 tons daily. The San Carlos mill, which now has a capacity of 1,800 tons daily, employs 160 workmen. Labor of this sort is generally paid from 35 to 60 cents per day without subsistence.

Men for the office force would probably have to be obtained outside the Philippines, in most cases. There are few engineers and chemists in the islands capable of operating centrals. The Filipinos are undoubtedly capable of acquiring the necessary training and experience, but modern sugar mills have not been in operation long enough in the islands to develop a supply of trained men to operate them. A number of Filipinos are now taking courses in chemistry and engineering in the United States and Europe, and these will doubtless help to supply the need in a few years. Just at present there are good openings in the islands for men who have had training and experience in the manufacture of centrifugal sugar.

The ordinary labor required is usually easily obtained, although it is often difficult to get cutters to harvest the cane crop and laborers to work about the old-fashioned sugar mills where the muscovado and pilon sugars are made. The explanation seems to be that wages paid by the central are usually a little higher than those paid for field labor or by the muscovado mills. These men are for the most part inexperienced in the work required about a central, and, therefore, are not very efficient, but the supply of experienced labor is increasing each year.

As new centrals are established workmen employed in some of those that have been operating for some time seek employment in the new enterprise in the hope of bettering their situations or for the mere desire to try something new, while new men take their places in the older factories.

Building and Machinery Costs—Private Transportation Equipment.

Mr. Cleve W. Hines, formerly sugar technologist of the Philippine Bureau of Agriculture, estimates that the buildings and machinery for a mill with a capacity of 800 tons per day would cost about $25,000. In this connection it should be remembered that cement and construction steel cost nearly 100 per cent more now than they cost before the war. The San Carlos central, including machinery and building material, was erected at considerably greater cost than it would have been before the war. Structural steel that before 1914 cost about $43 per metric ton now approximates $81, though with a tendency downward; corrugated iron roofing that cost $67 a ton in pre-war days now brings $150; cement has risen in this same period from $8 per ton to $12. Lumber and all builders' hardware have gone up proportionately.

Machinery imported from the United States into the Philippines pays no duty. It costs about as much to lighter or land freight in Manila as it would cost in an American port. Apparatus is not available for handling extremely large pieces. It must be borne in mind, however, that the points where the machinery is to be installed are usually far from Manila, and there are few facilities for loading and unloading heavy machinery in most of these places. Machinery designed for use on Negros, Panay, or Cebu probably would have to be transshipped at Manila on an interisland steamer for the port nearest the point where it is to be installed. Iloilo and Cebu each has some facilities for handling heavy cargo. From either of these points the machinery would probably have to be taken in lorchas or cascoes (native barges or lighters) towed by launch to connect with the land transportation necessary to get it to its destination. The cost of transportation from Manila to the point at which the machinery is to be installed depends, in each case, upon the location of that point and the conditions of local transportation at the time the machinery is received.

The larger sugar factories employ cars with trackage of the same gauge as that of the railroad in order to enable them to send their cars over the line when necessary. These cars carry approximately 20 tons of cane and are equipped with two sets of four wheels each. The factories also use a portable track of a much smaller type for conveying cane to the main lines. This ranges from 28 to 36 inches in width, and the cars carry from one-half to 2 tons of cane. These cars have but four wheels. Small locomotives are operated over some of these tracks and animal draft is provided for others. The three largest plantations have approximately 25 miles of heavy track and 6 or 8 miles of the light portable track; all of the small centrifugal sugar factories of Negros operate with a light track, and most of them run steam engines.

Methods of Marketing Philippine Sugar.

Before the introduction of the modern mill muscovado and pilon sugar was commonly sold by the planter to the exporters, usually Chinese merchants or European export and import houses, who maintain warehouses in Iloilo, the chief sugar port, for receiving and storing the stocks from the plantations. Sugar produced in Negros was commonly transported to Iloilo on barges towed by launches, while that produced along or near the railroad on Luzon was delivered by cart to cars at the nearest station. In the Visayan sugar regions the exporters usually advance money to the planters at certain times against the crops, and the planters are bound to sell their crop to the exporters at prices usually stipulated in advance, and, as a rule, very low. By the use of money made available by the Government, at first through the Bank of the Philippine Islands and later through the Philippine National Bank, the planter gradually ceased to be dependent upon the export merchant and has since been able to sell his output for the best price obtainable in the open market. The use of the modern mill for centrifugal sugar manufacture has brought about a change in the methods of marketing in many localities. It is now very common for the small planter to sell his share of the finished sugar to the central which does his milling. The central in turn frequently exports on its own account. At other times the central, or the larger planter who operates his own mill, sells to export merchants or brokers engaged in buying for foreign houses, and the increasing proportion of the pilon and muscovado sugar is now sold by the small planter to the large mills and centrals for conversion into centrifugal sugar.

On the whole, the Philippine sugar industry is being freed from the handicaps under which it has labored since its inception, and an entirely new life is being infused into it. Some conception of the field yet open in the islands for the installation of modern sugar machinery may be had by remembering that the exports of Philippine sugar are yet well under 300,000 tons per year (by far the greater portion of which is still manufactured by primitive methods), although those best informed concerning the area of land suitable for sugar culture in the islands estimate that the production may easily reach 1,000,000 tons annually.

[A list of modern sugar factories in the Philippine Islands, compiled at the beginning of 1919 and including both the mills actually in operation and those under construction or definitely planned for construction, may be obtained from the Bureau of Foreign and Domestic Commerce or its district and cooperative offices by referring to file No. 9879.]

[R. S. N.]

The Future of Industrial Alcohols.*

By B. R. Tunison.[1]

Introduction.

To attempt to predict the future of industrial alcohol is similar in many respects to making an attempt to foretell the outcome of a battle in a great war. The phases of the question are so numerous and complex and there are so many interdependent influences involved that any one would presume a great deal who attempted to predict with any degree of definiteness the future of industrial alcohol. However, if present influences are considered, it is possible to anticipate at least a few of the more important developments more or less accurately.

Importance of Alcohol Industrially.

The following statement, made by a joint select committee of Congress in its official report, is fully as true today as it was the day it was made, some twenty years ago.

"The uses of alcohol other than as a beverage are more largely and widely extended than is generally supposed. But while the use of alcohol as a beverage is purely voluntary its employment for all other purposes is legitimate, beneficial, and necessary. No article entering into manufacture or the arts, whether of domestic or foreign production, performs more legitimate or beneficial functions. There is scarcely a manufacturer in the country who does not use alcohol in the production of his goods to a greater or less extent."

Of the various alcohols which have been of industrial importance ethyl alcohol is unquestionably the most important. This alcohol has been subjected to severe trials in the past and burdened by taxes which have caused very great limitations to its legitimate uses. In the industries many costly substitutes have been made because pure ethyl alcohol was obtainable only at prohibitive prices, due to excessive taxes, and because the denatured grades were not suitable for many special purposes.

Production of Ethyl Alcohol.

Raw Material. The considerations which have determined the raw materials to be used in the manufacture of ethyl alcohol have been of a commercial nature rather than essentially chemical. At the present time the state of the art is such that from a chemical standpoint alcohol may be readily produced from nearly any available source of saccharine or starchy materials. To indicate the influence of local commercial conditions on the choice of raw material a few examples may not be out of place.

---

*Extracts from article in Journal of Industrial and Engineering Chemistry, April, 1920.
[1] U. S. Industrial Alcohol Co., 27 William Street, New York, N. Y.

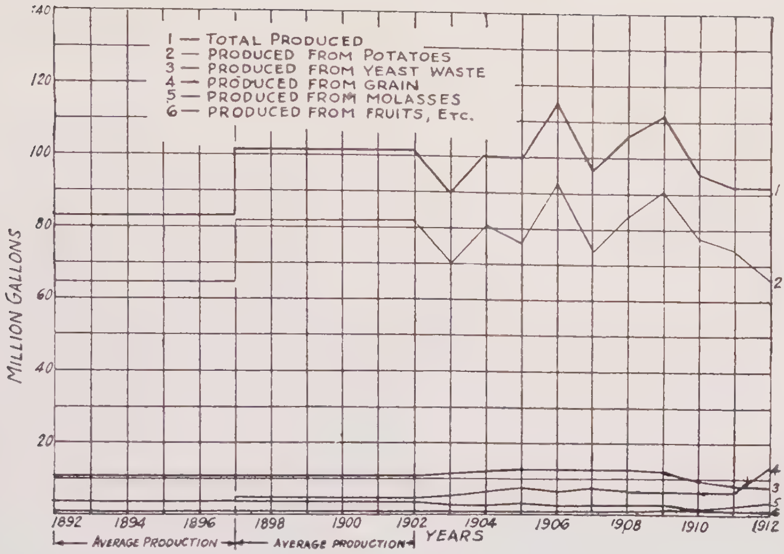


Fig. 1.

Production of Industrial Ethyl Alcohol in Germany, 1892–1912.

In Germany. The production of industrial alcohol in Germany has been a noteworthy example of the industry for some years. The production from the various raw materials is indicated in Table I and Fig. 1.

TABLE I—PRODUCTION OF ALCOHOL IN GERMANY (U. S. GALLONS)

Years	Potato Distilleries	Yeast Distilleries	Grain Distilleries	Molasses Distilleries	Fruit and Other Distilleries
1887/88—1891/92	59,826,000	10,190,000	3,065,000	3,330,000	686,000
1892/93—1896/97	63,362,000	10,370,000	3,615,000	3,620,000	898,000
1897/98—1901/02	81,730,000	10,900,000	4,750,000	3,190,000	872,000
1902/03	70,000,000	11,500,000	4,990,000	2,350,000	502,000
1903/04	80,420,000	12,060,000	6,204,000	4,410,000	608,000
1904/05	75,900,000	12,720,000	7,500,000	285,000	976,000
1905/06	92,820,000	12,670,000	7,000,000	219,000	819,000
1906/07	73,620,000	12,540,000	7,240,000	235,000	792,000
1907/08	83,100,000	12,770,000	6,440,000	272,000	1,005,000
1908/09	90,220,000	11,900,000	6,310,000	229,000	1,267,000
1909/10	77,600,000	9,460,000	6,150,000	1,936,000	1,005,000
1910/11	74,100,000	8,130,000	6,230,000	2,350,000	739,000
1911/12	66,000,000	7,925,000	13,100,000	3,380,000	898,000

Agricultural and labor conditions during the period indicated were such that potatoes were very cheaply produced and the saccharine material obtained therefrom on a per pound basis was relatively cheap, as compared, for example, with grains. Fruits had a higher value as food and the fruit wastes did not occur in

sufficient quantities to materially affect the alcohol production. The molasses available in Germany was largely beet molasses and had a somewhat greater value as a feeding material than as a raw material for alcohol production.

In France. In France sugar beets and beet molasses have been used to a considerable extent as a raw material for production of alcohol. The production from the raw materials used is shown in Table II and Fig. 2.

TABLE II—PRODUCTION OF ALCOHOL IN FRANCE (U. S. GALLONS)

Years	Raw Material			Total	Per Cent of Total Production in France
	Grain Distilleries	Molasses Distilleries	Beet Distilleries		
1908	9,560,000	12,620,000	33,300,000	55,500,000	81.5
1909	9,420,000	12,600,000	20,960,000	52,800,000	82.7
1910	12,200,000	13,350,000	31,200,000	56,800,000	90.0
1911	17,450,000	13,300,000	27,800,000	57,600,000	90.0
1912	23,300,000	12,300,000	42,800,000	78,400,000	89.3
1913	11,340,000	16,000,000	41,200,000	68,600,000	88.0
1914	21,700,000	9,940,000	12,370,000	35,700,000	81.5
1915	9,400,000	6,980,000	21,100,000	38,800,000	74.0
1916	17,560,000	4,100,000	11,900,000	33,600,000	81.6

In Switzerland. Consul W. P. Kent of Berne, Switzerland, has stated[1] that calcium carbide is being developed in Switzerland as a source of alcohol. He stated that installations were started with about 20,000 horsepower minimum and 30,000 horsepower maximum (summer time), which would produce from 7,500 to 10,000 tons of alcohol per annum. Calcium carbide is produced by the usual electric furnace method and acetylene from the calcium carbide by the action of water. Two methods are used in the production of alcohol from the acetylene:

1—Acetylene is hydrogenated by catalytic means and ethylene is produced. The ethylene is dissolved in sulfuric acid, and alcohol and sulfuric acid are formed upon saponification.

2—Acetaldehyde is produced catalytically from the acetylene. The acetaldehyde is oxidized to acetic acid or reduced to alcohol, by means of catalyzers. Great care is used in the selection of a catalyzer in order to eliminate numerous complicated side reactions which are liable to occur.

The production of alcohol by such processes as just described of course necessitates a very cheap source of power. This is available only in such places as Switzerland and Norway, and alcohol made by this means could not compete with alcohol of vegetable origin if such could be produced cheaply in those countries.

In the United States. In the United States many different materials are used with more or less successs. In some portions of the country corn and corn wastes are effectively and economically utilized. These products afford a con-

---

1 Commerce Reports, 102 (1917), 426.

venient and easily handled source of alcohol. For many years maize was the chief source of industrial alcohol in the United States, and undoubtedly corn and maize will continue to be a very important source.

Alcohol is being made from waste sulfite liquor in some localities where this waste is obtainable in quantity. Up until the present time the production has not been large enough to materially influence the alcohol market. This is largely due to the fact that there are very few places in the United States where sufficient waste liquor can be obtained to produce more than a few hundred gallons of alcohol per day.

So far as the writer is aware there are but two plants in operation in the United States producing alcohol from sawdust, and these have a relatively small production. There seem to be possibilities in the development of the production of alcohol from wood and wood waste.

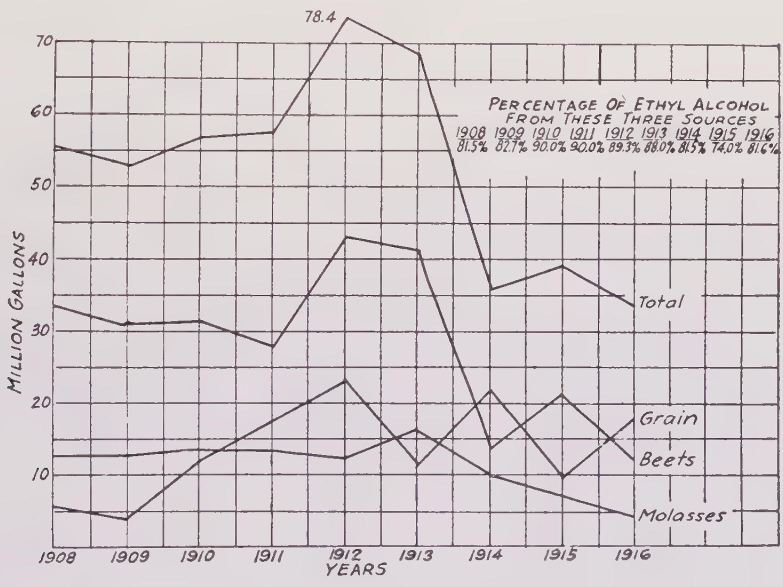


Fig. 2.

Production of Ethyl Alcohol in France.

During the last two years very little alcohol has been produced from the various grains. This is largely due to the fact that the grains are in demand as food materials at a high figure. In this country the only time it is feasible to use grains for the production of industrial alcohol is when a crop has been damaged in some manner so that it cannot be utilized as a food material.

Labor and agricultural conditions have been and are such in this country that potatoes cannot be grown economically enough to compete with trade wastes as sources of alcohol.

Fruit in this country is so valuable as food that it cannot be used as a source of industrial alcohol. Fruit wastes do not occur in sufficient quantity to supply even a centrally located distillery, and transportation of such products is of course not feasible.

TABLE III.—RAW MATERIALS FOR PRODUCTION OF ALCOHOL IN THE UNITED STATES

States and Territories	Raw Materials						Total	
	Corn Bu.	Rye Bu.	Malt Bu.	Other Materials Bu.	Molasses Gal.	Sulfite Liquors Gal.	Bu.	Gal.
California	1,656	....	....	....	13,223,826	....	1,656	13,223,826
Connecticut ...	1,767	1,622	1,311	....	....	....	4,700	....
Dist. Columbia	79,309	....	122,013	69,909	236,433	....	271,231	236,433
Hawaii	....	....	....	....	7,700	....	....	7,700
Illinois	8,130,912	29,770	880,135	44,993	4,219,519	....	9,085,810	4,219,519
Indiana	2,637,875	48,036	206,883	50,942	....	....	2,943,736	....
Kentucky	2,200,183	87,771	282,019	36	226,980	....	2,570,009	226,980
Louisiana	9,594	132	1,000	2,986	33,214,705	17,620,539	13,712	50,835,244
Maryland	130,522	2,734	5,176	....	34,626,539	....	138,432	34,626,539
Massachusetts.	2,690	2,418	1,272	....	13,118,139	....	6,380	13,118,139
Michigan	....	....	....	....	....	5,290,164	....	5,290,164
Missouri	13,967	1,986	2,444	....	....	....	18,397	....
Montana	....	....	....	....	249,340	....	....	245,340
New York	342,150	37,712	69,158	....	11,025,740	28,637,832	449,020	39,663,572
Ohio	578,451	3,170	63,324	784	....	....	645,729	....
Pennsylvania..	295,793	7,116	33,213	....	7,873,097	....	363,122	7,873,097
Rhode Island..	....	....	....	7	5,942	....	7	5,942
South Carolina	....	....	....	2,382	....	16,958,609	2,382	16,958,609
Texas	....	....	....	....	....	20,098	....	20,098
Wisconsin	119,676	26,397	21,729	....	....	....	167,802	....
Total	14,544,545	248,864	1,689,677	172,039	118,027,960	68,527,242	16,665,124	186,555,202
Total for Fiscal Year 1917 ..	33,973,268	3,375,439	4,239,677	81,435	112,497,633	78,462,969	40,669,819	190,960,602

SUMMARY.

	Gal.
1913	193,606,258
1914	181,919,542
1915	140,656,103
1916	253,283,273

Sugar beets and beet molasses have not been used to any extent for the production of industrial alcohol in this country, because at present they are utilized for feeding purposes and they cannot compete with other trade wastes.

The chief source of industrial alcohol in the United States is cane, or black strap, molasses. Only a few years ago, especially in the East and West Indies, the disposal of molasses by the sugar mills was a serious trade waste problem, but it is now very largely used the world over as a raw material for alcohol manufacture. The conversion of molasses into alcoholic liquor, especially into rum, is an old enterprise. West India rum has been famous in New England for more than 200 years. But the use of molasses in large quantities for industrial alcohol production is a development of the last few years. As far as ease of manipulation is concerned, molasses unquestionably surpasses any other

known material. Moreover in the past it has been a very cheap material. A large portion of the world's molasses is still a waste product due to the difficulty and expense of transportation to the commercial centers.

Molasses from Cuba and Porto Rico is of special importance to the United States, because of the several million tons which are annually available for the production of alcohol. This molasses is gathered from the various producing mills in barges, steam lighters, hundreds of tank cars, and in some few cases barrels and hogsheads, and taken to the large storage tanks which are located at deep water shipping ports. Tank steamers, such as are used for the transportation of petroleum, are used to carry the molasses from these storage points to various plants in the United States: in Boston, New York, Baltimore, New

TABLE IV—PRODUCTION OF ALCOHOL IN THE UNITED STATES

States and Territories	1918			1917
	From Materials other than Fruit—Gal.	Fruit Brandy Gal.	Total Production Gal.	Total Production Gal.
California	8,727,694	5,295,952	14,023,646	17,851,482
Connecticut	23,527	2,924	26,451	132,055
District of Columbia	749,517	....	749,517	608,812
Hawaii	3,935	....	3,935	14,016
Illinois	49,679,940	140	49,680,080	79,320,617
Indiana	15,820,031	10,899	15,830,930	43,361,276
Kentucky	12,604,703	3,734	12,608,437	36,441,778
Louisiana	24,406,539	....	24,406,539	26,545,832
Maryland	26,746,386	....	26,746,386	24,965,321
Massachusetts	10,873,375	....	10,873,375	12,511,238
Michigan	752,745	....	752,745	819,908
Missouri	77,026	2,501	79,527	289,661
Montana	186,248	....	186,248	244,773
Nebraska	....	....	....	2,938,594
New Jersey	....	51	51	54,494
New Mexico	....	....	....	315
New York	10,540,421	4,480	10,544,901	13,856,054
Ohio	3,277,485	36,618	3,314,103	10,114,573
Pennsylvania	7,293,914	....	7,293,914	12,190,764
Rhode Island	2,845	....	2,845	224
South Carolina	943,568	....	943,568	1,159,309
Texas	7,281	....	7,281	13,905
Virginia	....	....	....	122,957
Wisconsin	759,294	....	759,294	2,527,249
Wyoming	....	26	26	260
Total	173,476,474	5,357,325	178,833,799	286,085,464

Orleans, and other points. In addition to the above-mentioned sources of molasses large quantities are obtained from the cane sugar refineries located in the southern and southeastern parts of the United States.

The various raw materials used and the quantities of alcohol obtained from them are indicated in Tables III and IV.

The figures are, of course, totals and include the beverage alcohol production.

The total production of ethyl alcohol in various countries from 1908 to 1912 is shown graphically in Fig. 3.

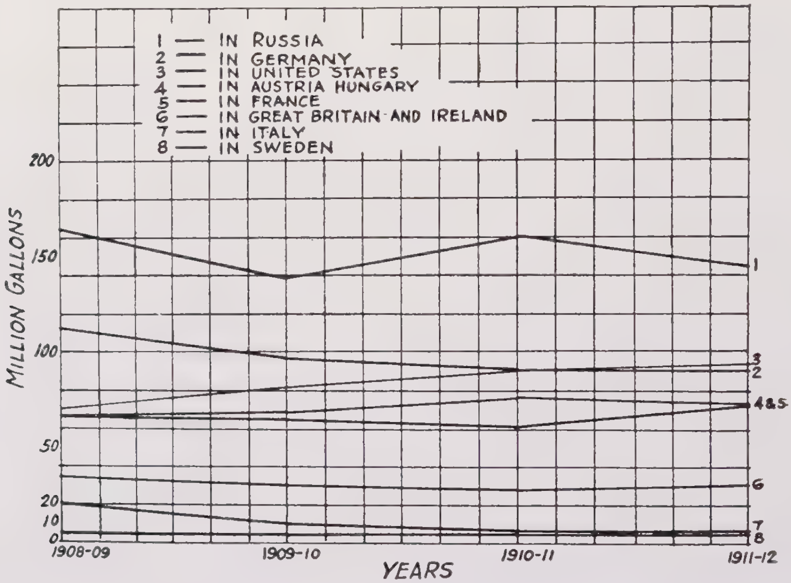


Fig. 3.
Production of Ethyl Alcohol, 1908–1912.

Production of Denatured Alcohol.

In the last few years the production and consumption of denatured alcohol in the United States has increased very greatly, as shown by Table V and Fig. 4.

TABLE V—PRODUCTION OF DENATURED ALCOHOL IN THE UNITED STATES

Fiscal Years	Denaturing Warehouses	Completely Denatured Wine Gal.	Specially Denatured Wine Gal.	Total Wine Gal.	Total Proof Gal.
1907	8	1,397,861	382,415	1,780,276	3,084,950
1908	12	1,812,122	1,509,329	3,321,451	5,640,331
1909	12	2,370,839	2,185,579	4,556,418	7,967,736
1910	12	3,076,924	3,002,102	6,079,027	10,605,870
1911	14	3,374,019	3,507,109	6,881,129	11,682,887
1912	14	4,161,268	3,933,246	8,094,515	13,955,903
1913	21	5,233,240	4,608,417	9,831,658	16,953,552
1914	25	5,213,129	5,191,846	10,404,975	17,811,078
1915	23	5,386,646	8,599,821	13,986,468	25,411,718
1916	33	7,871,952	38,807,153	46,679,108	84,532,253
1917	44	10,508,919	45,170,678	55,679,597	93,762,422
1918	49	10,328,454	39,834,561	50,163,016	90,644,722

The falling off in the quantity of denatured alcohol used during 1918 is accounted for by the fact that in the early part of the year several of the larger munition plants discontinued the manufacture of explosives for the Allies, in which denatured alcohol had been used, and engaged in the manufacture of explosives for the United States Government, using principally tax-free undena-

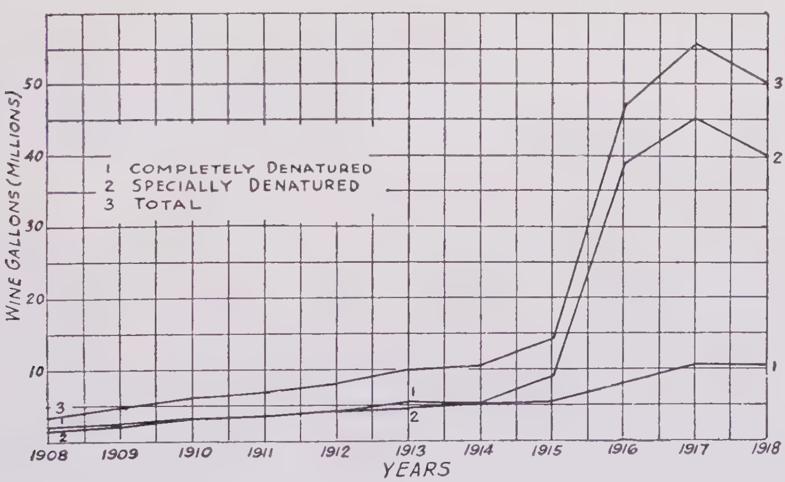


Fig. 4.
Production of Denatured Alcohol in the United States.

tured alcohol. The army specifications were subsequently changed and denatured alcohol was used exclusively in those plants. The quantity of denatured alcohol used during the year in the manufacture of explosives and for other war purposes was approximately 52,847,117 proof gallons.

Manufacture From Raw Materials.

The alcohol industry as it stands today is the result of a very long period of development. The methods and apparatus used have become pretty well standardized and no revolutionary changes or developments are anticipated. Many minor improvements are being made from time to time, but as far as the distillation and rectification are concerned the principles involved have been carefully worked out and apparatus designed which correctly applies them.

A large amount of research is being directed towards the processes of fermentation and we may hope for many developments from this phase of the industry. Paralleling this development, better systems of plant control will undoubtedly be put into practice. While the yields obtained at present are good, better results are being searched for.

Uses of Industrial Alcohol.

As far as the influence of the industries in which alcohol is used is concerned, the use of alcohol in the future should develop fully as rapidly as the industries themselves. If this were the only, or even the most important factor, as it is concerning most commodities, the prediction of the future would be a relatively simple matter. Most of the newly developed chemical industries in this country have come to stay and they will require an ever-increasing quantity of alcohol.

While most of the uses of alcohol will be developed more or less parallel with the development of the chemical and allied industries, there are a few the expansion of which will be more or less revolutionary in character.

Solidified Alcohol. One of the very important uses today, and one that is becoming increasingly so, is that of solidified alcohol. Alcohol burns with a smokeless flame and does not carbonize like kerosene, so that even at the present time it is a very satisfactory fuel, and its only rival for chafing dishes, coffee percolators and such articles is electricity. In regions where electricity is not available solidified alcohol is a very important fuel for cooking purposes. It is also used very extensively during vacation trips to the mountains or the seashore. It is very convenient to handle and is without dirt, smoke, or odor, and is an economical fuel, and undoubtedly the use of alcohol in this form will increase to a very marked degree.

Purification of Turpentine. One of the newer developments is the utilization of alcohol in the separation and purification of gum-turpentine. The present method of heating and making the crude products at the turpentine camps results in rosin of which only a small part is of good color. It has been found that the crude gum-turpentine is readily soluble in high proof denatured alcohol. It is then possible to remove such foreign matter as particles of wood, twigs, insects, etc., which have been found largely responsible for coloring the finished products. Subsequent distillation of the gum-turpentine-alcohol solution results in a separation of the alcohol heads containing a small percentage of turpentine, which functions as a denaturant and at the same time produces a product which can be used again as a solvent. The turpentine fraction is clear and marketable as a high-grade product and the rosin residue is colorless and of the highest

grade. The loss of solvent at present is approximately 6 per cent and developments indicate that it may become lower. When using this process it is possible to centralize the processing of the gum-turpentine and thus reduce operating expense to a minimum. The increase in quantity of high-grade products, the very small losses involved, and the small cost of operation incurred by this process indicate that it will become of very great importance in the turpentine industry.

Ethylene. Another relatively new development in the utilization of alcohol is in the catalytic production of ethylene. Ethylene has been considered as a substitute for a cutting and welding gas in the place of acetylene. From comparative tests ethylene is found to have many advantages over acetylene. As far as the heat of combustion is concerned ethylene has a slightly higher value. In cutting and welding iron and steel ethylene has among others the following advantages:

1—It has a high ratio of carbon to deterrent element like hydrogen, overcoming the tendency to retard combustion and slow the cutting.
2—It has a rapid rate of combustion, preventing loss of temperature from absorption and conduction of heat by the metal being cut.
3—It will help to maintain an oxidizing effect fast enough to overcome any tendency to burn too deeply or chill the surfaces of the metal being cut.
4—It will produce a rapid rate of cutting with a low consumption of gas, making a high efficiency possible from the regular operators of the torch.
5—It shows a decrease of labor and gas consumption with increase of thickness of metal cut, making the cutting of thick metal as economical as thin metal.
6—It possesses a remarkable degree of lightness of the charged cylinders, providing a valuable portability and ease of movement of the gas supply about a shop.
7—It is a non-poisonous, safe gas, without objectionable odor.
8—It has a clearly outlined cone in the flame, without which a workman would be badly handicapped.

In the working of copper it has been impossible to make a satisfactory weld with acetylene, because of the formation of carbon and the consequent blistering in the weld. Perfect copper welds have been obtained with ethylene.

In aluminum welding and lead burning ethylene is infinitely better than acetylene. There is no carbon formation and no kick back in the burner, while a terrific heat may be maintained.

It is a much safer gas to handle, since it does not explode spontaneously. It can be compressed and handled in the standard form of gas cylinder without either packing or a solvent (acetone). For this reason it is possible to make a saving of about one-half in the cost of the cylinders and approximately one-half in the freight cost. Furthermore, ethylene can be compressed so that a cylinder will hold over 200 cu. ft. of ethylene. Thus the cost per cubic foot for shipment is again cut in half. Ethylene is essentially a "one man" gas. The weight of ethylene per 100 cu. ft., including the container, is only 40 lbs., as compared to 90 lbs. for acetylene. A cylinder of ethylene weighing between 80 and 85 lbs. contains approximately 210 cu. ft. of gas and can be easily handled by one man.

Ethylene is being sold at the same price as acetylene. It may be used in an ordinary welding torch, but preferably one with a mixing chamber. A change in the size of the tip is also desirable.

In addition to the use of ethylene as a cutting and welding gas it has been found to have considerable value for lighting and heating purposes where electricity is not available.

In the chemical industries we all realize that with a source of cheap, pure ethylene it will be possible to manufacture a great number of synthetic and chemical products.

Internal Combustion Engines. Probably the use of alcohol which in the future will have the greatest significance is its use as such, or in admixture with other compounds, as a fuel for internal combustion engines. For years volumes have been written about the use of alcohol in such engines. In Germany, where the supply of petroleum products was inadequate and where alcohol was a relatively cheap commodity, large quantities were used for automotive and power purposes. In France alcohol was used extensively for automotive engines. In the United States considerable has been said about using alcohol for automobiles, farm machinery, etc. Vivid word pictures have been drawn of the farmers taking their waste products and processing them in their small plants and then doing everything from sawing wood to doing the family washing with alcohol as a source of power. However, the petroleum supplies in this country have been so abundant and available at such reasonable prices that these word pictures have remained as such and the farmers continue to buy gasoline with which to operate their automobiles and small engines. This has been the case since the agitation for alcohol production by the farmers in 1906–7.

Recently, however, conditions have suddenly changed. The Geological Survey tells us that in about three years the peak in a curve showing petroleum production will be reached and after that time there will be a gradual decline in petroleum production over a long period of years.

Not only will the production of petroleum continually decrease, but the present indications are that the demand for petroleum products will increase in the next few years even more rapidly than ever. The increase in the number of automobiles, trucks, tractors, and airplanes during the last five years has been remarkable. If the increase from now on is only a small percentage of what it has been we must soon obtain a new supply of explosion engine fuel, and while our supply of petroleum is limited in quantity, the raw materials for the production of alcohol are around about us in inexhaustible quantities. At this time the utilization of alcohol for power purposes appears very significant.

While it will probably be several years before alcohol alone will be used as a motor fuel, alcohol in admixture with other fuels is now being produced and marketed in some localities of this country. The alcohol fuels as used at present do not require a specially designed engine to obtain optimum results, but the standard engine and accessories are used with excellent results. Alcohol fuels have many advantages over gasoline when used in automotive engines, some of which may be summarized as follows:

Greater mileage;
No preignition;

No knocking;
More uniform application of power during power stroke of piston;
More power;
Power more completely under control.

Even though the alcohol has a lower B. t. u. value for the heat of combustion, the combustion of the fuel is more complete and greater efficiencies are obtained. This is especially true in slow speed engines such as motor trucks.

Alcohol fuels have also been developed for airplane use. In this regard the Journal of the Society of Automotive Engineers[1] says in part:

> A new alcoholic fuel, consisting of alcohol, benzol, and ether, is about to take the place of the high-grade airplane gasoline, which has previously been used in the Air Mail Service.
>
> The advantage of this fuel lies in the resulting cleanliness of the engines, reduction in the cost of upkeep and its burning cooler than gasoline, which to some extent overcomes the objection to a high-compression engine when operating at low altitudes. It requires about four-fifths as much of the new fuel for any given distance and altitude. This gives greater flying radius to the planes and will enable the DeHaviland Fours to cover the New York to Cleveland route, a distance of 430 miles, in a non-stop flight. It reduces the probability of forced landings by keeping the spark plugs and the engine cylinders clear of carbon deposits and accumulations of oil.

As the realization of the advantages of the above-mentioned fuels becomes more universal, and as the quality of the gasoline becomes poorer due to the diminishing petroleum supply, and as the price of gasoline rises, alcohol will be used in greater and greater quantities. In anticipation of this great increase in the demand for alcohol for power purposes we should take active steps to assist in the development of the alcohol industry so that an adequate supply of alcohol may be at hand when needed.

Probable Effect of Legislation on the Future of Industrial Alcohol.

The effect of the passage of the industrial alcohol bill in 1906 had a marked effect on American industries in which alcohol is used. Many new enterprises were undertaken and those in operation were greatly extended. Since 1907 these industries using alcohol have prospered and grown until the United States, instead of being one of the smallest nations from an industrial alcohol point of view, has now become one of the greatest world influences. The increase in the production of industrial alcohol since 1907 is summarized in the last two columns of Table V.

While the progress made by the alcohol industry has been little short of remarkable, our chemical industries which depend very largely on a supply of cheap alcohol have not prospered as have those in some other countries. The bill of 1906 was an important step forward, but the manufacture, sale, distribution, and use of alcohol was so surrounded with rules and regulations that many manufacturers did not use it and the normal growth of the industry was never approximated.

---

[1] Journal of the Society of Automotive Engineers, 5 (1919), 207.

When the present prohibition bill was being discussed and prepared the very existence of the industries using industrial alcohol was threatened. The Commissioner of Internal Revenue, with very great foresight and with a realization of the necessity of a supply of alcohol for industrial purposes, the use of which should be as free of restrictions as possible, prepared and presented the section of the prohibition bill relating to industrial alcohol. The assistance given by the Internal Revenue Bureau in showing the necessity of industrial alcohol, and the absolute dependence of some industries on a supply of alcohol, to those concerned with the making of our laws was a cooperation with the chemical and allied industries which should be known and appreciated by every chemist. A great deal of credit should be given to members of the present Congress who took time to learn facts concerning some of the industrial phases of the alcohol question, with the result that the industrial alcohol section of the bill was passed.

Now that a new law is to govern the alcohol industry we may feel certain that the Internal Revenue Bureau will proceed in the same manner in drafting the rules and regulations which are to surround the manufacture, sale, distribution, and use of alcohol. We may feel confident that the Government's taxable interests will be protected and at the same time the manufacturers will be given the greatest possible freedom in the use of alcohol for industrial purposes. Due to the attitude of fairness of the Internal Revenue Bureau, it is not too much to expect that we shall have alcohol under such conditions as will be an added stimulus to the progress of our rapidly growing chemical industries.

Aside from the natural growth of the alcohol industry care should be taken to foster its development. We are told that we should maintain a policy of preparedness throughout the coming years. Now that the whiskey distillery is to be a thing of the past, where could we look for a supply of alcohol in case of war? In the recent war the distilleries came to the rescue, and in case of another war we must have industrial alcohol plants in operation which could immediately supply large quantities of a most necessary product.

It has been said that the future increased production of alcohol could be attained by persuading the farmers to produce alcohol in small agricultural distilleries in a manner similar to those in operation in Germany. There are several reasons why this is not likely to take place. Labor is very much higher in this country than in Germany. The farmers of this country have become accustomed to production on an extensive scale rather than in an intensive manner, and are not likely to be satisfied with the results of a small distillery. In order to obtain satisfactory results the fermentation must be carefully controlled, and the average farmer does not possess sufficient technical training to do this effectively. The manipulation of an alcohol plant is difficult except to a technical man. These farm installations would necessarily be small units because of the limited quantity of raw material available, the cost of the installation would be high, the labor cost would be excessive, the output would be small, and the unit cost of production would be so high that the farmer could buy alcohol cheaper than he could make it. Our case is quite different from that of Germany, where these conditions do not exist, and where the industry has been subsidized by the gov-

ernment. Without such subsidy and government pressure it is the writer's opinion that the farmers of this country are not likely to produce alcohol for industrial purposes for some time.

Alcohol is essentially a cheap commodity and should be treated as such. Today this is not the case, and the manufacturer may be partly to blame for this condition. If manufacturers using alcohol in quantity would buy alcohol as they buy other commodities in tank car lots and not require shipment in expensive cooperage or steel drums, they would help to remove the impression that alcohol is such a valuable product. The ordering, billing, shipping, returning, crediting, etc., of these packages is a nuisance as well as a source of considerable expense. Alcohol is the only product in the history of the United States which has been taxed several hundred per cent of its value. This has given the impression that industrial alcohol is also extremely valuable. As the uses of alcohol are developed and as it becomes used more extensively for such purposes as motor fuel, it is not too much to expect that it should be handled in much the same manner as petroleum and its products. Great Britain is beginning to realize that alcohol is essentially a cheap product and should be treated as such. The British Inter-Departmental Committee on the Production and Utilization of "Power Alcohol" recommends in part the following:

> As the price of alcohol for power and traction purposes, to which we propose the name of "power alcohol" should be given, must be such as to enable it to compete with gasoline, it is essential that all restrictions concerning its manufacture, storage, transport, and distribution should be removed so far as possible, consistent with safeguarding the revenue and preventing improper use, and that cheap denaturing should be facilitated.
>
> Finally, we are of opinion that steps to facilitate the production and utilization of power alcohol in the United Kingdom can in no circumstances be taken, nor arrangements for such development carried into effect, unless provisions and alterations of the kind we recommend in our report are made in *advance* of the time when an acute recurrence of high prices for motor fuels may otherwise call for action too late for it to be effective.

Why should not the common carriers in this country as well as our Government recognize that industrial alcohol is a 50-cent commodity and not one of $5.00 value? Why shouldn't manufacturers assist in bringing about such a recognition by using the specially denatured alcohols wherever possible and not be frightened by such words as "permit," "bond," and similar words identified with the Internal Revenue Bureau. The Commissioner of Internal Revenue is the friend of the manufacturer using alcohol and not his enemy. He will endeavor to assist you and not retard your progress. Over forty formulas of specially denatured alcohol have been authorized for use in the manufacture of over 350 articles in addition to many class authorizations. The Commissioner of Internal Revenue will consider the authorization and the extension of the use of any formula in new industries or will consider the authorization of new formulas, if existing formulas are not applicable. As long as the Government's taxable interests in the alcohol are protected it may be freely used by the industries.

The requirements of the Internal Revenue Bureau surrounding the use of specially denatured alcohol are neither difficult nor prohibitive. The papers may

be easily prepared. If you are a user of alcohol why shouldn't you take advantage of your privileges and assist in the stabilization and progress of our American chemical industries?

If the United States builds up a large industrial alcohol production and fosters its growth and development the industries will benefit, and there is no question but that this nation as a world power will be stronger. During peace the nation will be strong because of its industries; during war these industries using alcohol will be instantly available as the media for the production of war materials.

Conclusions.

In the preceding paragraphs it has been possible to mention only a few of the probable influences affecting the future of industrial alcohols, and to attempt to indicate in a general manner their effect on the future. Now that the realization of the necessity of industrial alcohol is becoming more general, legislation favorable to manufacturers is taking place and the industries using alcohols are developing rapidly. May we not look forward to the time when the industry of making industrial alcohols in the United States will be of such magnitude as to be a great national asset under all conditions? [R. S. N.]